

PASSAIC RIVER STUDY AREA
ECOLOGICAL SAMPLING PLAN

Work Plan/Field Sampling Plan

Combined Sewer Overflow Investigation
Post-Trial Run Update

December 2000

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Supplement

This document presents modifications to pertinent sections of the March 1999 Ecological Sampling Plan (ESP) Work Plan (1999 ESP Work Plan). The revised text incorporates information gathered from the January 2000 CSO Trial Run Program, which was conducted pursuant to the 1999 ESP Work Plan.

Specifically, this document includes modified versions of the following ESP sections:

- 2.5 Combined Sewer Overflow Investigation
- 2.10.3 CSO Effluent Analytes
- 2.10.4 CSO Solids Analytes
- 3.2.3 Combined Sewer Overflow Sampling
- Standard Operating Procedure No. 6 – Bulk Sampling Methodology
- Standard Procedure No. 14 – In-Line Sediment Trap Methodology

In addition to the above, the following documents are attached to supplement the revised text:

- Attachment 1 – Information on Laser Diffraction Particle Size Analysis
- Attachment 2 – March/July 1999 QAPP, Revised Table 4-2
- Attachment 3 – CSO Trial Run Recommendation Report (July 21, 2000)
- Attachment 4 – Results of Centrifuge Comparison Test (September 20, 2000)

2.5 Combined Sewer Overflow Investigation

2.5.1 Rationale/Data Quality Objectives

Combined sewers are conduits that transport treated or untreated sanitary and industrial wastewater during dry weather conditions and combined wastewater and storm water runoff during wet weather periods to municipal treatment facilities, *i.e.*, publicly owned treatment works (POTWs), as well as to the receiving waterbody when the capacity of the POTW is exceeded. In general, POTWs are not designed for the large quantities of combined wastewater that may result during storm conditions, or sometimes even periods of moderate precipitation. Under such conditions, the excess wastewater that cannot be treated at the POTW(s) is typically diverted via regulator chambers directly to the receiving waterbody. The regulator chambers are usually located where local sewerage districts join the CSO trunk line. Figure 2-7 illustrates a typical combined sewer collection network.

It is well known that CSO effluent can contribute substantially to total chemical loading in a riverine system (EPA, 1994; EPA, 1980). Current evidence suggests that the lower Passaic River is subject to substantial chemical loadings from CSOs that may adversely impact surface water and sediment quality (Walker et al., 1999; Huntley et al., 1997; Iannuzzi et al., 1997; Shear *et al.*, 1996; Crawford *et al.*, 1995).

The CSO sampling program described herein involves collection of settleable solids samples from CSOs that discharge into the six mile Study Area. The data obtained from collecting and analyzing these samples will provide information regarding the types and concentrations of chemicals that are discharged to the Study Area from ongoing pollution sources. It is anticipated that these data will be used to estimate CSO contributions of contamination in the Study Area under current and future conditions. The estimated contributions of CSOs to contamination in the Study Area will be used in evaluating the effectiveness of remedial alternatives in the Feasibility Study (FS).

2.5.1.1 Locations of CSOs in Study Area

Locations of the 30 CSOs that discharge to the Study Area are depicted in Figures 2-1 through 2-6. Twenty-nine of these 30 CSOs are operated by the Passaic Valley Sewerage Commission (PVSC), and one CSO (Roanoke Avenue) is operated by the City of Newark. The available physical and flow data for these CSOs are presented in Table 2-1. The data in this table were reported by the PVSC in 1976 (PVSC, 1976). Although the PVSC continues to routinely monitor and collect this information, it has not been published. These 30 CSOs discharge within the five navigation reaches of the Study Area as described below.

Point No Point Reach

The Point-No-Point Reach contains one CSO. Data are not available at this time on the specific size of this CSO's tributary area.

Newark Reach

There are 12 CSO outfalls that discharge into the Newark Reach of the Passaic River. Six of these outfalls are located in the municipality of Newark and six are in Harrison. These 12 CSOs combined serve a total tributary area of 1,159 acres.

Harrison Reach

There are seven CSO outfalls that discharge into the Harrison Reach of the Passaic River. Two of these outfalls are located in the municipality of Newark, one in Harrison, and four in Kearny. Combined, these seven CSOs serve a total tributary area of approximately 1,302 acres.

Kearny Reach

There are nine CSO outfalls that discharge into the Kearny Reach of the Passaic River. These nine CSOs combined serve a total tributary area of approximately 2,420 acres.

Table 2-1

Historical Combined Sewer Overflow Information for the Passaic River Study Area^a

WP/FSP
Revision 5.0
December 2000
Page 1 of 1

Overflow location	Usage ^c	Tributary Area (acres)	% of Area with Combined Sewers (%)	Base Flow		Minimum Overflow Duration (hrs)	Maximum Overflow Duration (hrs)	Estimated Maximum Storm Capacity (mld)	Estimated Maximum Overflow Capacity to River (mld)	Maximum Peak Overflow to River (mld)
				Dry Weather Months (mld)	Wet Weather Months (mld)					
Point no Point Reach ^b										
Roanoke Ave										
No Data Currently Available										
Harrison Reach ^b										
Freeman Street (N)	R&I	149	100	3.79	4.54	0.50	6.42	209.31	209.31	60.56
Polk Street (N)	R&I	199	100	6.17	6.28	0.67	3.25	2218.01	1491.29	234.67
Worthington Avenue (H)	I&R	177	95	7.65	10.60	NA	NA	34.07	34.07	34.07(est.)
Dukes Street (K)	R&I	25	100	0.64	0.76	0.83	3.12	36.34	32.93	24.60
Tappan Street (K)	R&I	35	100	1.32	1.55	0.30	4.83	35.96	22.71	32.93
Bergen Avenue East (K)	R&I	110	100	2.35	2.73	4.33	22.48	85.92	85.92	109.77
Ivy Street (K)	I&R	607	85	11.36	13.25	0.25	9.92	986.75	986.75	923.54
Newark Reach ^b										
Jackson Street (N)	R&I	83	100	4.01	4.01(est)	0.50	1.33	658.59	658.59	253.60
Middlesex Street (H)	I&R	62	100	2.73	3.71	0.27	3.95	21.95	21.95	47.69
City Dock (N)	I&R	380	100	37.02	44.13	0.50	1.83	1934.14	1550.71	420.14
Bergen Street (H)	I&R	72	100	3.14	4.28	0.70	1.67	41.64	41.26	63.21
Dey Street (H)	I&R	6	100	0.34	0.45	0.66	2.83	6.43	6.43	30.28
Harrison Avenue (H)	I&R	67	100	2.91	4.09	0.75	6.80	111.28	111.28	75.70
Cleveland Avenue (H)	I&R	11	100	0.53	0.72	0.22	2.22	24.98	37.09	46.18
Rector Street (N)	I&R	177	100	7.12	7.19	0.25	23.83	923.54	1566.99	257.38
Saybrook Place (N)	R&I	306	100	18.24	18.55	0.40	5.25	1419.38	1570.78	336.87
New Street (H)	R&I	32	100	0.64	1.25	0.83	3.13	26.12	26.12	68.13
Bridge Street (N)	R&I	10	100	negligible	negligible	NA	NA	23.85	51.48	none
Orange Street (N)	R&I	13	100	negligible	negligible	NA	NA	60.18	143.45	none
Kearny Reach ^b										
Clay Street (N)	R&I	1621	56	102.95	119.61	1.50	17.50	2753.21	1854.65	1275.55
Central Avenue (EN)	R&I	26	100	0.53	1.02	0.28	1.75	164.27	164.27	233.16
Johnston Avenue (K)	I&C	207	80	2.38	3.03	0.50	4.27	632.10	462.91	423.92
Passaic Street (N)	NA	31	100	1.14	1.29	NA	NA	18.93	NA	26.50
Marshall Street (K)	I&C	24	100	0.34	0.45	0.65	2.75	10.60	10.60	18.93
Fourth Avenue (N)	R&I	225	100	6.06	7.38	0.25	13.17	992.05	271.01	234.67
Third Avenue(N)	R	8	100	Included in 4th Avenue		NA	NA	12.87	9.84	See 4th Avenue.
Nairn Avenue (K)	R&I	176	85	2.04	2.61	0.75	1.63	31.42	9.84	9.84
Bergen Avenue West (K)	R&I	12	10	0.19	0.23	0.50	4.00	38.23	79.49	9.08
Arlington Reach ^b										
Herbert Place (N)	R&C	298	100	4.54	7.00	0.41	11.50	513.25	1393.26	416.35

NOTES:

^a Information from PVSC, 1976.^c Primary Usage of Street (in order of importance)^b Letter after location denotes municipality of CSO:

(N) Newark

R - residential

(K) Kearny

I - industrial

(H) Harrison

C - commercial

(EN) East Newark

NA - Not Available

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Arlington Reach

There is one CSO outfall that discharges into the Arlington Reach of the Passaic River. This CSO has a tributary collection area of 298 acres.

Field observations made during reconnaissance events indicate that it is not practicable to sample any of these 30 CSOs at the point at which they discharge into the Study Area. For this reason, this program has been developed for sampling the CSOs from accessible manholes that provide access to the CSO outfall pipes.

2.5.1.2 Data Use Objectives and Analysis

As described previously, the purpose of collecting CSO effluent data is to gather the information necessary for the FS to evaluate the degree to which CSO effluent may adversely impact surface water and sediment quality in the Study Area, and to support the qualitative assessment of future risk in the HERA. A critical step in this analysis is the derivation of an estimate of the annual total mass loading (g/yr) of each chemical into the Study Area from CSOs. The annual total loading is the sum of the annual loadings from each individual CSO. Under this ESP, annual loadings from individual CSOs will be based on three estimates or measurements: 1) a representative chemical concentration in the solid (particulate) fraction of the CSO effluent (mg chemical/Kg particulate); 2) a representative suspended particulate concentration (Kg particulate/L effluent); and 3) the estimated volume of effluent discharged from the CSO (L) during the year. The manner in which these values will be derived for the Study Area is described in detail below.

2.5.1.2.1 Representative Chemical Concentrations

Representative chemical concentrations in CSO effluent will be calculated using one of several possible methods, depending on the nature of the data that are ultimately obtained. Data obtained from analysis of the collected solids (mg chemical/Kg particulate) are preferred. If these data are not obtained for a particular group(s) of chemicals because of insufficient sample mass, then the chemical concentration in the particle fraction will be taken as the difference between the concentration measured in the filtered vs. the unfiltered

effluent sample. If data are not available for a particular CSO(s), then a chemical concentration for the solids fraction from that CSO(s) will be estimated from the concentrations measured at the other sampled CSOs that discharge into the Study Area. To the extent practicable, the estimated concentrations will be derived from CSOs that are similar in size of drainage area, composition of source (industrial vs. residential), nature of source (types of industry), and other relevant features.

2.5.1.2.2 Total Suspended Solids Concentration

The total suspended solids (TSS) concentration (Kg particulate/L effluent) will be measured in each CSO that is sampled. For any unsampled yet operable CSO, TSS will be estimated from data collected at other CSOs as described above. The TSS data will be used to estimate the mass loading of solids from CSOs to the Study Area.

2.5.1.2.3 Volume of Effluent

The volume of effluent discharged per overflow event per CSO will be taken directly from PVSC monitoring records or will be estimated using CSO-specific characteristics, local rainfall patterns, and the EPA's Storm Water Management (SWM) Model. Each overflow event will be categorized as a "dry" or "wet" overflow event, based on an evaluation of precipitation records prior to the overflow event. Overflows that occurred with less than 0.1 inch of precipitation in the preceding 48 or more hours will be considered dry weather overflow, all others will be considered wet weather overflows. A total annual volume for dry and wet weather overflow can thereby be estimated by summing the individual events.

2.5.1.2.4 Deriving an Annual Loading Estimate

For each operable CSO, there will be a chemical concentration and suspended solids value that are obtained from the sampling results. The total estimated annual volume of effluent discharged (V) (calculated as described above) multiplied by the representative chemical concentration (CC) and suspended solids (SS) values estimated from sampling results will yield an estimate of the total mass loading of chemicals (M) that

occurred for the year. The annual loading for the entire Study Area will be the sum of the annual loadings of all operable CSOs. While this method does not account for the fraction of loading that may be associated with dissolved chemicals in the effluent, it is not likely that this fraction is significant to the total loading, relative to that from the solids, for most of the chemicals groups being analyzed under this ESP.

2.5.1.2.5 The SWM Model

The EPA's SWM model is capable of simulating movement of precipitation and pollutants from the ground surface through pipe and channel networks, storage/treatment plant units and finally to the receiving water. Both single event or continuous simulation may be performed on catchments having storm sewers, combined sewers and natural drainages for prediction of flows, stages, and pollutant concentration. It can also be used as a planning model for overall assessment of urban runoff and proposed abatement options. Design-level, event simulations can be performed using detailed catchment schematization and shorter time steps for precipitation input.

The SWM model is widely used in the United States to estimate CSO discharge volumes and the PVSC is currently required to use the model as part of their permitting process as previously described. If it becomes necessary to estimate discharge volumes using a model, the SWM or the best available methods at the time will be used. It is anticipated that discharge volumes will be obtained from the PVSC. Only if these data cannot be obtained from the PVSC will the SWM model be run under this ESP.

2.10.3 CSO Effluent Analytes

Table 2-3 summarizes the analytical program for the effluent samples to be collected from CSOs that discharge into the Study Area. To evaluate overall water quality, analyses will be performed on both filtered and unfiltered samples for a select suite of chemical parameters. In addition to the chemical analyses described in this section, each unfiltered CSO effluent sample will be analyzed for the physicochemical and water quality parameters described in Section 2.10.2.

Table 2-3. Summary Of Analytical Suite For CSO Effluent Samples

Chemical Analyses	Other Analyses
Semivolatile Organics	Total Suspended Solids (TSS) (unfiltered only)
Pesticides and Aroclor PCBs	Total Organic Carbon (TOC) (unfiltered only)
PCB Congeners and Homologues	Dissolved Organic Carbon (DOC) (filtered only)
Chlorinated Herbicides	
PCDDs/PCDFs	
Total Extractable Petroleum Hydrocarbons (TEPH)	
Inorganics and Cyanide	
Organotins	

The purpose and usefulness of the analyses described in Table 2-3 (other than chemical analyses as they apply to the objectives of this ESP) are briefly described below.

- **Total Suspended Solids (TSS):** Suspended solids provide a direct binding surface for chemicals, particularly hydrophobic organic compounds, in the water column. TSS provides a direct measure of the amount of solids that are present in the water column. By combining TSS with TOC measurements, an estimate can be made of the partitioning of chemicals onto solids in the water column. In addition, TSS is necessary to calculate a mass loading of contaminants from the CSOs into the Study Area.
- **Total Organic Carbon (TOC):** Organic carbon content can affect the sorptive capacity of a material for organic compounds, thereby influencing the chemicals fate in the environment (Burton, 1992). TOC will be analyzed on unfiltered water samples, with the result representing both the dissolved organic carbon and the organic carbon associated with the total suspended solids.
- **Dissolved Organic Carbon (DOC):** DOC will be analyzed on filtered portions of the CSO effluent samples. DOC is an index of the colloidal phase in water samples that can influence the bioavailability of chemicals in water by acting as a partitioning phase, like the suspended sediments.

The methods for the handling, collection, and preparation of filtered and unfiltered CSO effluent samples are described in Section 3.0.

2.10.4 CSO Solids Analytes

Table 2-4 summarizes the target analytical program for the solids samples to be collected from CSOs that discharge into the Study Area. If sufficient mass is not obtained at a particular CSO to conduct all of the targeted chemical analyses (*i.e.*, if less than 270 g dry weight are obtained), then a hierarchical order of analyses for solids samples will be followed as depicted in Table 2-5.

Table 2-4. Summary of Analytical Suite for CSO Solids

Chemical Analyses	Other Analyses
Semivolatile Organics	Total Organic Carbon (TOC)
Pesticides and Aroclor PCBs	Percent Moisture
PCB Congeners and Homologues	Grain Size
Chlorinated Herbicides	
PCDDs/PCDFs	
Inorganics and Cyanide	
Organotins	
Total Extractable Petroleum Hydrocarbons (TEPH)	

Table 2-5. Analytical Hierarchical Prioritization for CSO Solids Samples¹

Analyses	Minimum Sample Dry Weight Required (g)^{2, 5}
PCDDs/PCDFs	50
PCB Congeners and Homologues	50
Inorganics and Mercury	5
Percent Moisture	5
Pesticides and Aroclor PCBs	30
Semivolatile Organics ³	30
Chlorinated Herbicides	30
Cyanide	10
Total Extractable Petroleum Hydrocarbons (TEPH)	20
Organotins	15
Total Organic Carbon (TOC)	20
Grain Size ⁴	300, 5

NOTES:

¹Prioritization following PCDD/PCDFs and PCB congeners and homologues is based on the estimated relative importance for chemical analysis in solid samples under this ESP.

²If sufficient mass is not obtained for a specific analysis in the relative priority order, then an alternative analysis of lower priority and that requires less mass may be performed.

³PAH analyses will be conducted using GCMS/SIM methodology (as specified in the QAPP) to improve sample quantitation limits.

⁴Grain size analysis using ASTM procedures requires a minimum of 300 grams of solids (dry weight). If insufficient mass is collected as required by the ASTM procedure, the grain size analysis will be conducted using laser diffraction methodology, which requires 5 grams of solids (dry weight). See Attachment 1 for a complete description of this methodology.

⁵Table 4-2 of the QAPP has been modified to incorporate these revised minimum sample dry weights, and is included as Attachment 2.

The methods for collection of CSO solids samples are discussed in detail in Section 3.2.3. The analytical methods to be utilized under this ESP are discussed in Section 7.0 of the QAPP, and copies of the methods are provided in Appendices A through T of the QAPP. The quality assurance and control procedures for analysis of CSO solids samples will be performed in strict accordance with those specified for sediment samples in the QAPP.

3.2.3 Combined Sewer Overflow Sampling

In accordance with the 1999 USEPA-approved ESP Work Plan, a CSO Trial Run Program was conducted at a single CSO to determine the most effective means of collecting CSO settleable solids. Between December 1999 and March 2000, two sets of CSO settleable solids samples were obtained at the Saybrook Place CSO: one in accordance with SOP 6 (bulk sampling method), and the other utilizing SOP 14 (in-line sediment traps). [Note: Both SOPs represent the original procedures defined in the March/July 1999 ESP Work Plan].

A summary of the CSO Trial Run Program was submitted to the USEPA as part of the CSO Trial Run Recommendation Report (July 21, 2000), and is included herein as Attachment 3. As presented in Attachment 3, the Trial Run provided much needed insight into the logistics of implementing this sampling effort on a larger scale. Overall, the bulk sampling methodology (SOP 6) proved to be a more valid approach, as it produced a better representation of solids from the Saybrook Place CSO discharge (i.e., in general, sediment traps tended to collect materials and particles that were much coarser in nature).

As a result, a phased Full-Scale Sampling Program which utilizes bulk sampling as the primary collection methodology will be implemented. However, to further substantiate the Trial Run findings, in-line sediment traps will again be placed in select CSOs during the initial stages of work. For purposes of the Full-Scale CSO Sampling Program, SOP 6 has been modified to reflect modifications resulting from the Trial Run Program, and to allow for more efficient collection procedures.

Therefore, as part of the initial sampling phase, all specified aqueous and solids samples will be collected using both SOP 6 – Bulk Sampling Methodology and SOP 14 – In-Line Sediment Trap Methodology. Pending results of the physical and chemical analyses, sediment traps will be considered for use in subsequent phases of the program. Should results from this initial phase indicate that modifications to any of the methodologies are necessary, the Agencies will be notified.

Sampling Logistics

Settleable solids samples will be collected from the CSOs via manholes that provide access to the CSO outfall pipes. An attempt will be made to gain access to manholes for all of the 30 CSOs that discharge into the Study Area. The manhole station will be located below the weir, sediment trap, or other flow-limiting structure that is associated with the main trunk line of the CSO network (see Figure 2-7). As necessary, due to access or other limitations (*e.g.*, property restrictions, physical constraints within the manhole, health and safety concerns, etc.) that may prohibit sampling at a preferred manhole station, alternative manholes will be evaluated for sampling the same CSO(s). The appropriate permits for entering manholes will be obtained from the PVSC, as necessary. If the necessary access permits cannot be obtained, then the scope of this ESP may be modified.

Bulk Sampling Method (SOP 6)

Under the Bulk Sampling Method (SOP No. 6), three types of samples will be targeted for collection from each of the bulk CSO samples including:

- Unfiltered effluent samples
- Filtered effluent samples
- CSO solids.

Table 3-5 provides a summary of all effluent and solids analyses.

Table 3-5. Summary of Chemical Analytical Program for CSO Samples

Analytical Parameter	Unfiltered effluent samples	Filtered effluent samples	Solids¹
Semivolatile Organics	T	T	T
Pesticides and Aroclor PCBs	T	T	T
PCB Congeners and Homologues	T	T	T
Chlorinated Herbicides	T	T	T
PCDD/PCDFs	T	T	T
Organotins	T	T	T
Inorganics and cyanide	T	T	T
Total Organic Carbon	T		T
Dissolved Organic Carbon		T	
Total Suspended Solids	T		
Total Extractable Petroleum Hydrocarbons (TEPH)	T	T	T
Grain Size			T
Percent Moisture			T

NOTES:

¹CSO solids will be centrifuged/filtered only if a sufficient mass of settleable solids cannot be obtained.
T - target analytes.

If a sufficient mass of solids to perform a full analytical suite cannot be collected from a particular CSO, then the difference in the chemical concentrations between the unfiltered and filtered effluent samples will be considered to be representative of the chemical concentrations on the solids matrix for the analyses not performed.

For the Bulk Sampling Method (SOP No. 6), a minimum of one “dry weather” and one “wet weather” overflow sampling event will be conducted at each operable and accessible CSO. Dry weather overflows typically contain higher chemical concentrations than wet weather overflows because of “washout” of particles that have accumulated in streets and other land surfaces. A “dry weather” overflow refers to storm-related overflow that occurs following an extended period of little or no precipitation. This term must not be confused with “dry weather discharge” which, for the purposes of this ESP, refers to non-storm related discharges that occasionally occur (due to illegal discharge, leaking pipes, etc.). For the purposes of this ESP, a dry weather overflow event will be storm-related overflow that occurs following a minimum of 48 hours of less than 0.1 inch precipitation. This is consistent with EPA guidance concerning “dry vs. wet” weather (EPA, 1985). Other storm-related overflow events will be considered wet weather overflow events.

Automated monitoring equipment will be used to collect precipitation data throughout the Full-Scale Sampling Program. In addition, tidal information, associated with the timing of overflow/sampling at each CSO, will be obtained from government sources.

Bulk effluent samples will be collected using either a semi-automated sampling methodology or a manual sampling methodology, as described in SOP 6. For collection of the bulk effluent sample at each CSO, trailer-mounted sampling units containing pumping equipment, polyethylene bulk water storage tank(s), sensors and electrical equipment will be deployed prior to anticipated precipitation events. Bulk water storage tank(s) will have sufficient capacity (minimum 600 gallons based upon the Trial Run Program) to obtain the required solids mass. During equipment set-up, the pump and sensors will be installed in appropriate locations within the CSO. At certain locations, subgrade piping will be required between the sampling unit and the CSO. At these CSOs, installation of the piping will require roadcutting.

Flow depth, water velocity, conductivity, dissolved oxygen, and pH will be measured at each CSO. Flow depth, water velocity, and the CSO geometry will be used to calculate flow volume. This information will be obtained for both a dry storm and a wet storm event for each operable and accessible CSO discharging to the Study Area, resulting in two sampling events for each operable and accessible CSO. Figure 3-1 shows

the logic flow chart for the analytical program. Once the bulk sample has been collected, the trailer and holding tank will then be returned to the staging area for processing. Once at the sample processing facility, filtered and unfiltered effluent samples will be collected from the holding tank and sent to the laboratory for the following analyses (Table 3-5):

- Water quality parameters on an unfiltered effluent sample
- Chemistry parameters on an unfiltered effluent sample
- Chemistry parameters on a filtered effluent sample.

Water volumes filtered during the collection of the filtered effluent samples will be recorded.

Subsequent to the collection of the effluent samples, the holding tank may stand for up to 48 hours, allowing time for the suspended solids to settle at the bottom of the tank. Settled solids, if sufficient mass is present, will be removed from the tank by appropriate means.

If insufficient mass is obtained from the collection of settled solids for the planned chemical analyses, the bulk effluent sample will undergo centrifugation or filtration to collect additional solids. In the event that only a limited mass of solids (that is not sufficient to perform a full analytical suite) is collected from a particular CSO, the hierarchical order of solids analyses, as described in Section 2.10.4, shall apply.

Alternatively, the bulk storage tank may immediately be processed by centrifugation or filtration (i.e., not utilizing the 48-hour settling period).

CSO In-Line Sediment Trap Sampling (SOP 14)

Detailed protocols for implementation of the in-line sediment trap collection method are included in SOP 14. Although SOP 14 is not intended to be utilized as the primary CSO sampling methodology, it may be implemented in the early stages of the program to gain further insight into the feasibility of such an approach.

If the in-line sediment traps are used for CSO sampling, then estimates of chemical concentrations in CSO discharges on an annual basis will be based on direct measures of chemistry and TSS from a time-integrated sample collected for a period of up to of 120 days. This integrated sample will represent the combined wet and dry weather discharges over that period.

Legend

- 20 CSO Outfalls (Approximate)
- 8 Stratified Random Stations
- ▲ 13 Judgmental Sampling Stations
- ▨ Mudflat Areas

CSO Outfall Key

1. Roanoke Ave

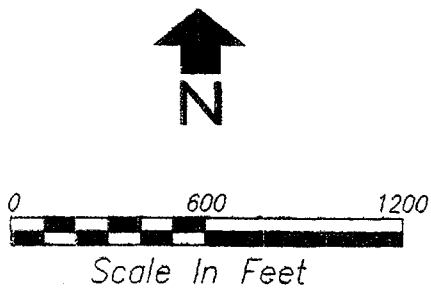
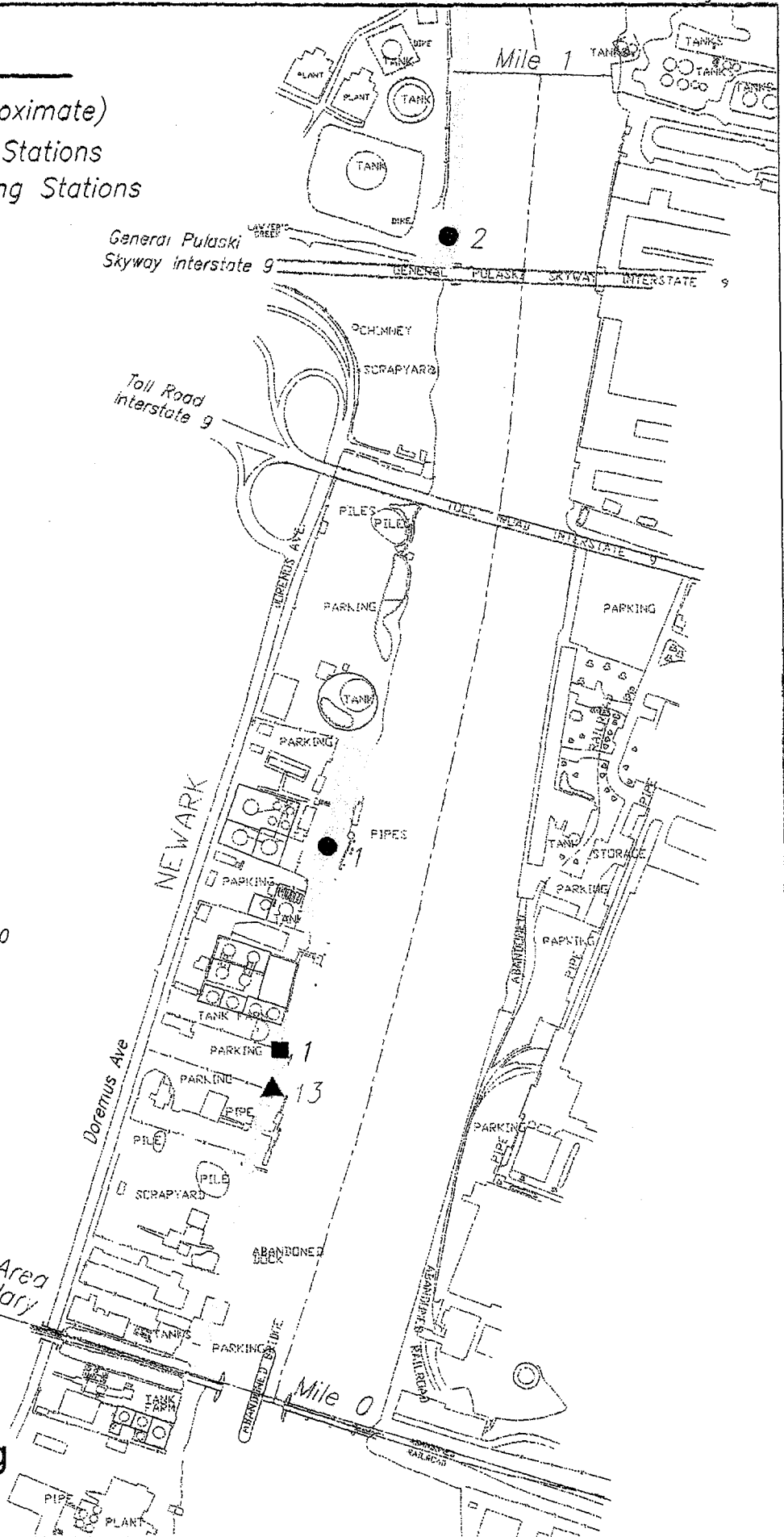


Figure 2-1
Approximate Sampling
Stations for the ESP



Legend

- 20 CSO Outfalls (Approximate)
- 8 Stratified Random Stations
- ▲ 13 Judgmental Sampling Stations
- ▨ Mudflat Areas



Scale In Feet

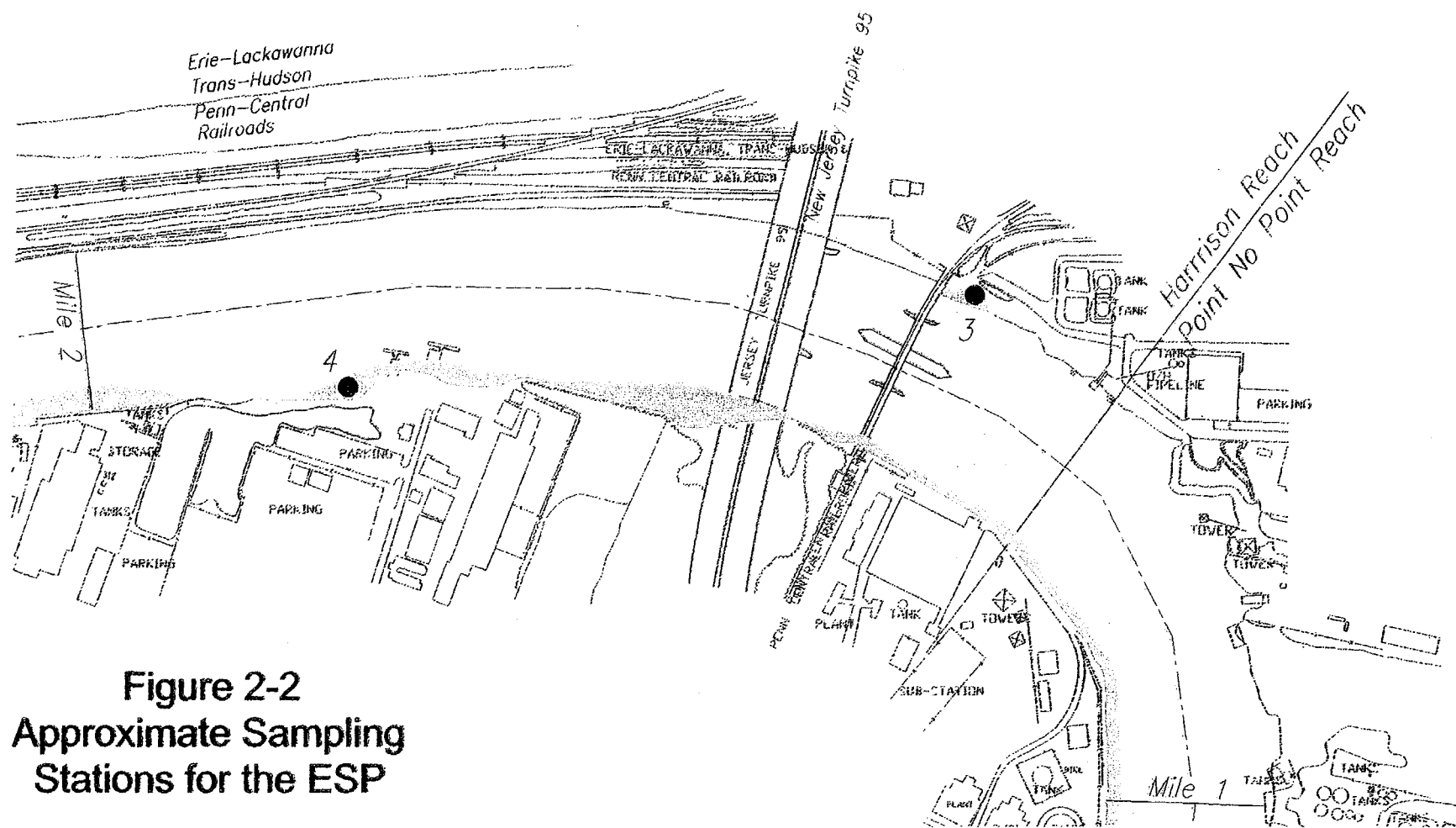


Figure 2-2
Approximate Sampling
Stations for the ESP

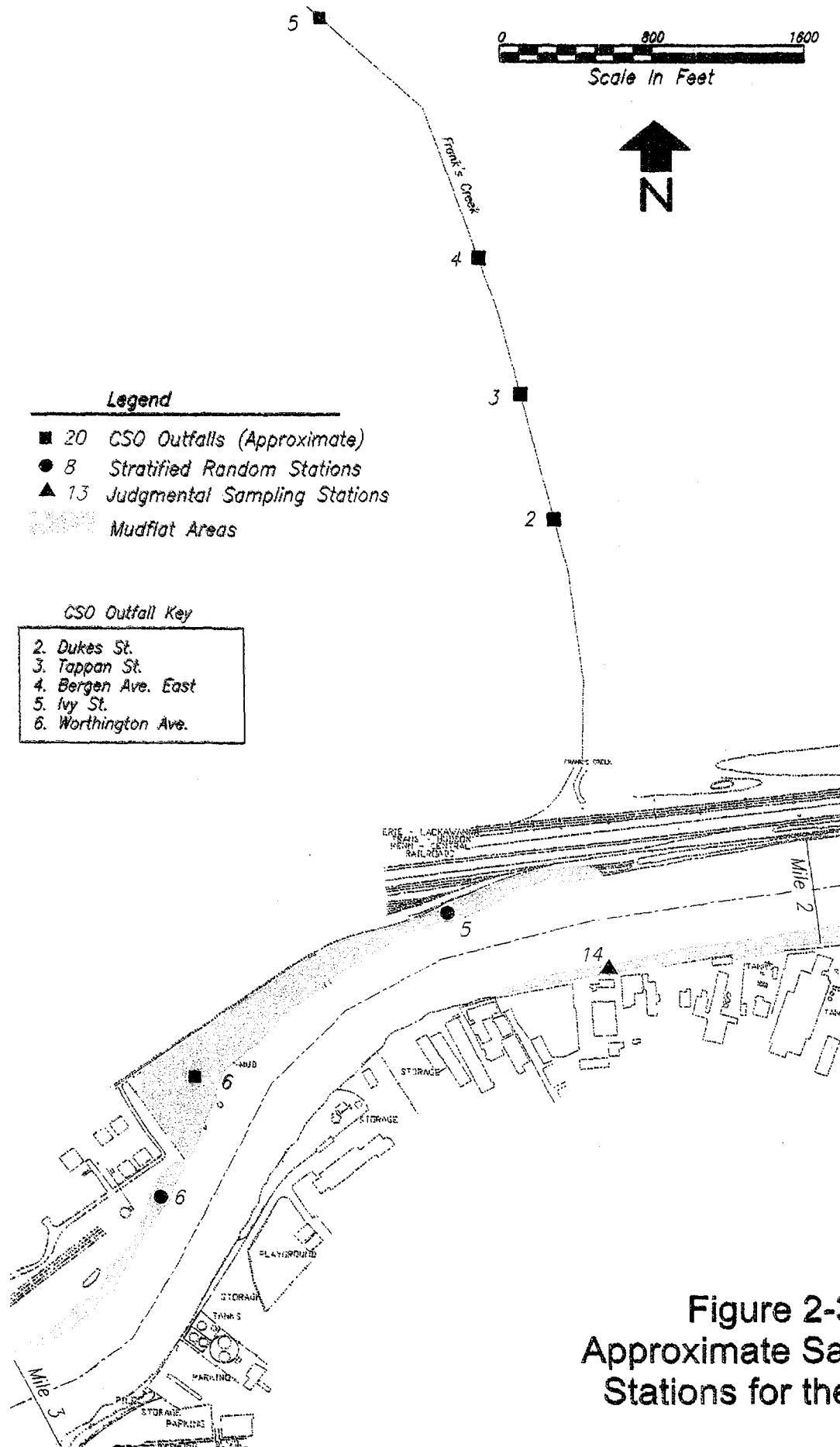
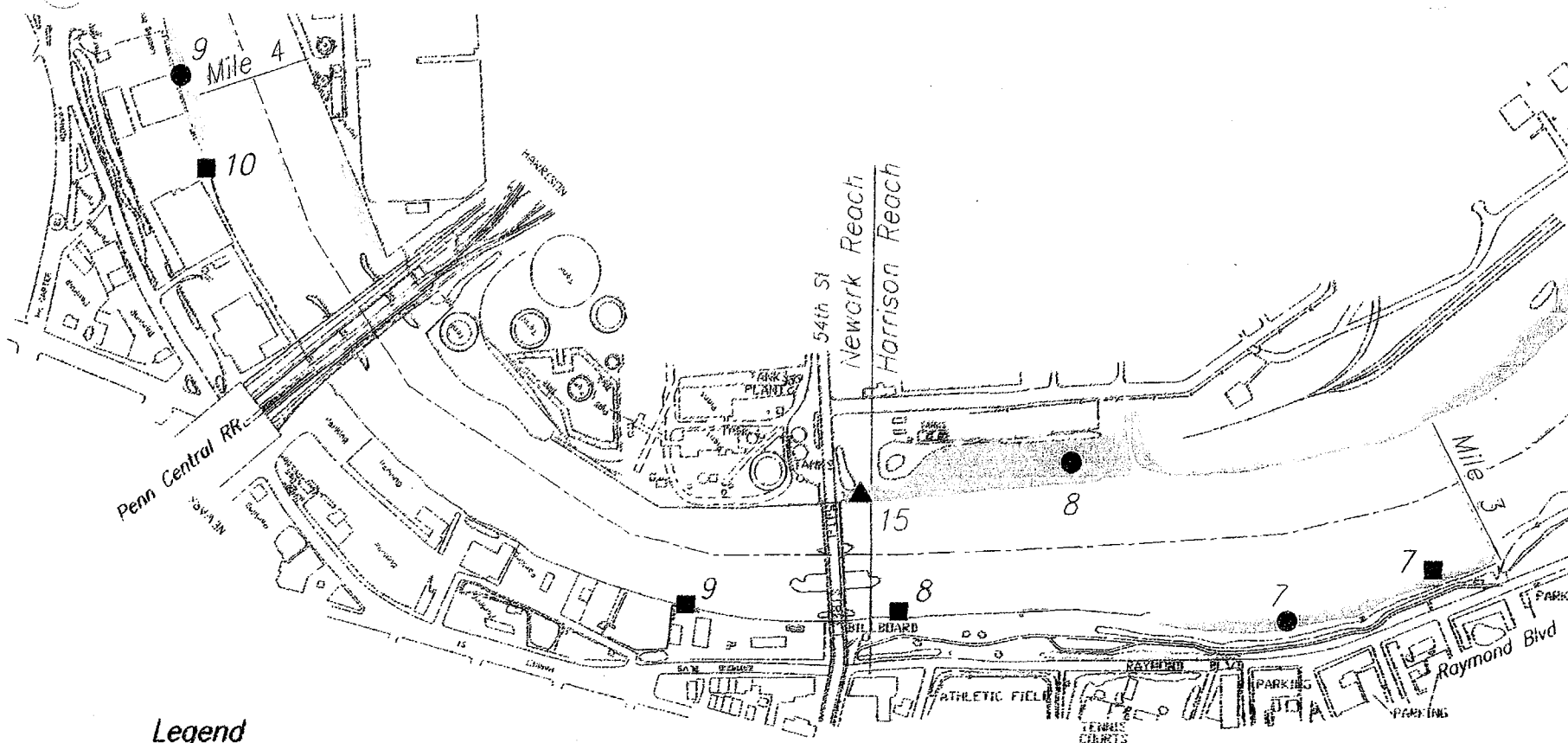


Figure 2-3
Approximate Sampling
Stations for the ESP



Legend

- 20 CSO Outfalls (Approximate)
- 8 Stratified Random Stations
- ▲ 13 Judgmental Sampling Stations
- ▨ Mudflat Areas

CSO Outfall Key

- 7. Freeman St.
- 8. Polk St.
- 9. Jackson St.
- 10. City Dock



0 600 1200
Scale In Feet

Figure 2-4
Approximate Sampling
Stations for the ESP

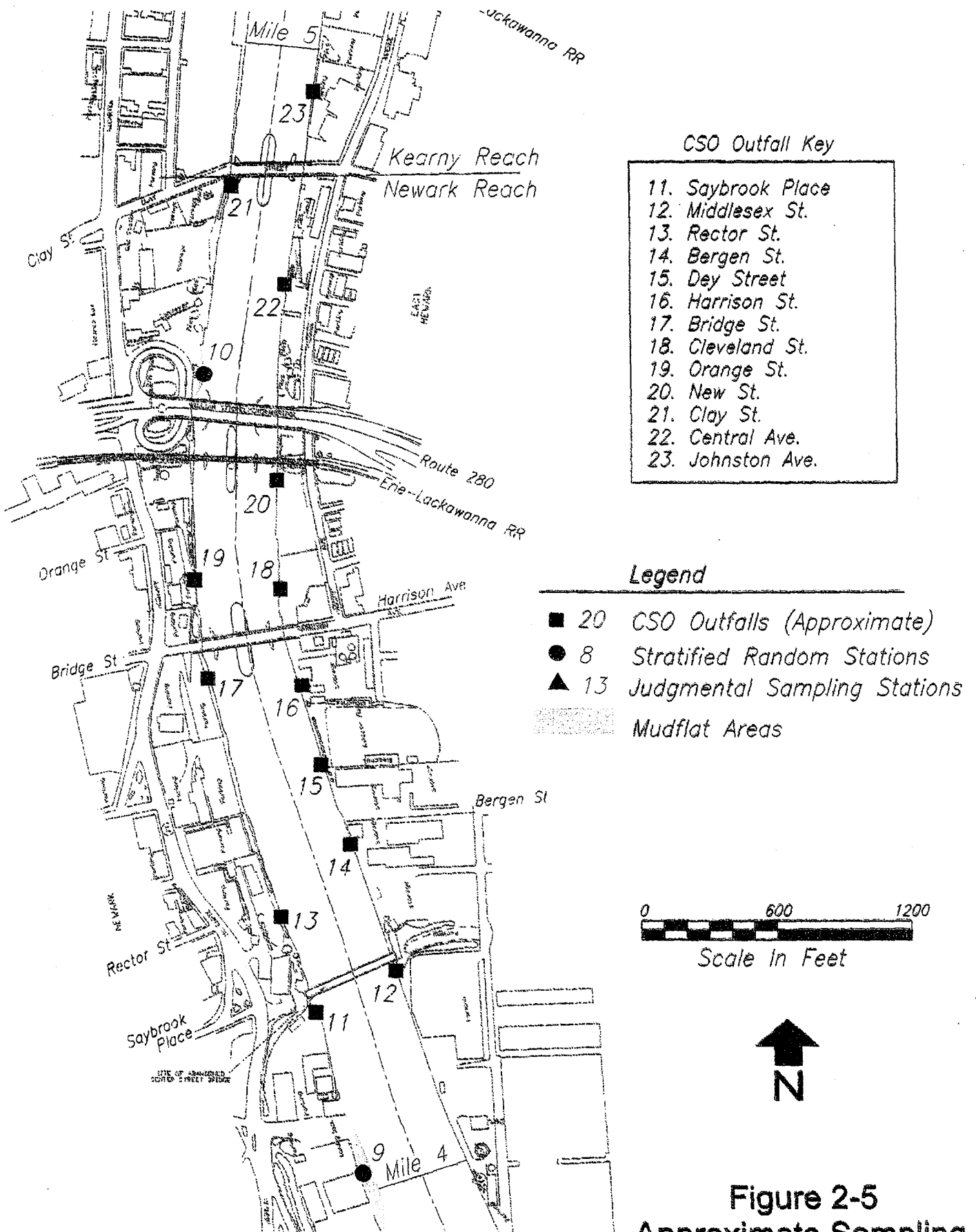


Figure 2-5
Approximate Sampling
Stations for the ESP

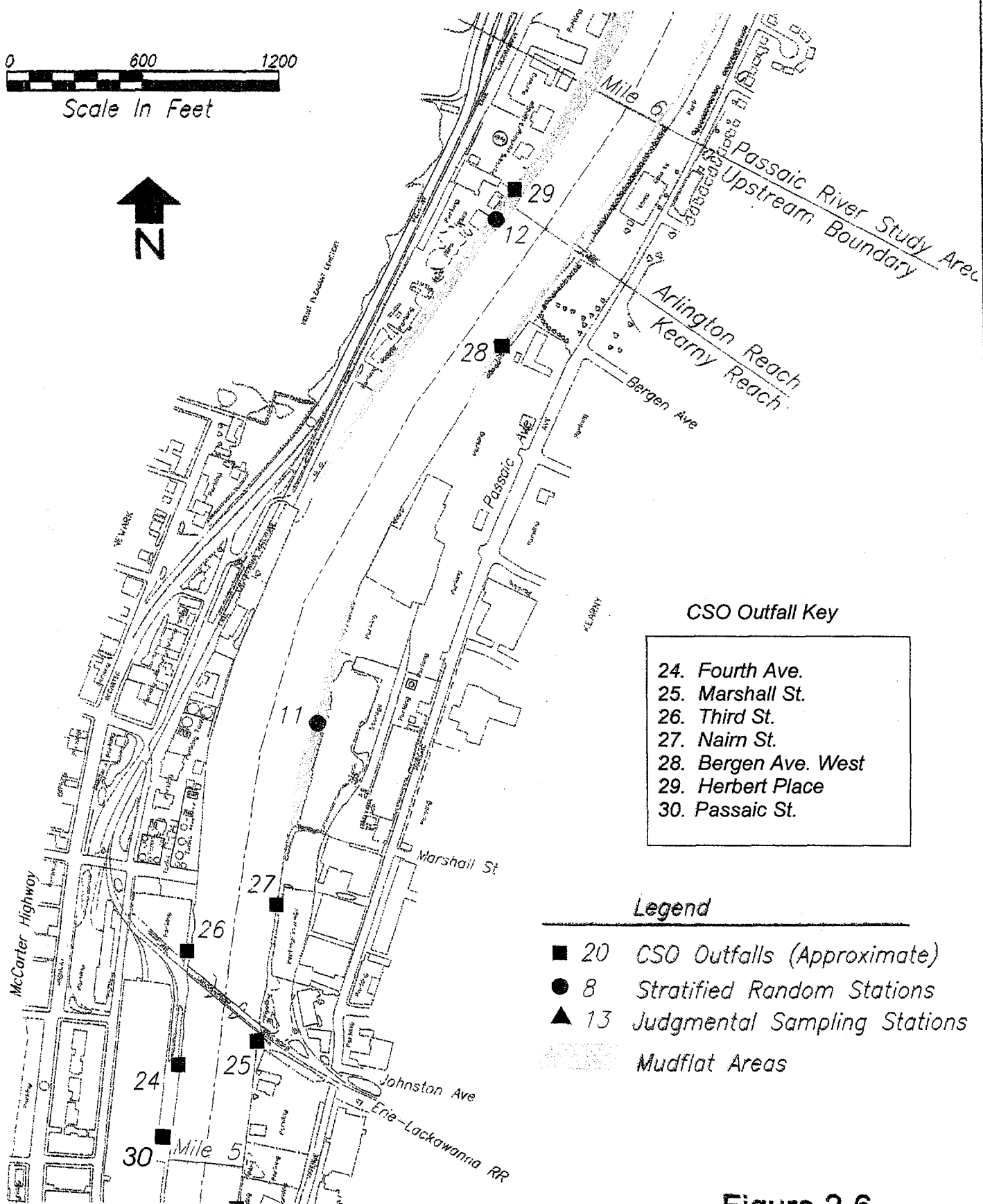


Figure 2-6
Approximate Sampling
Stations for the ESP

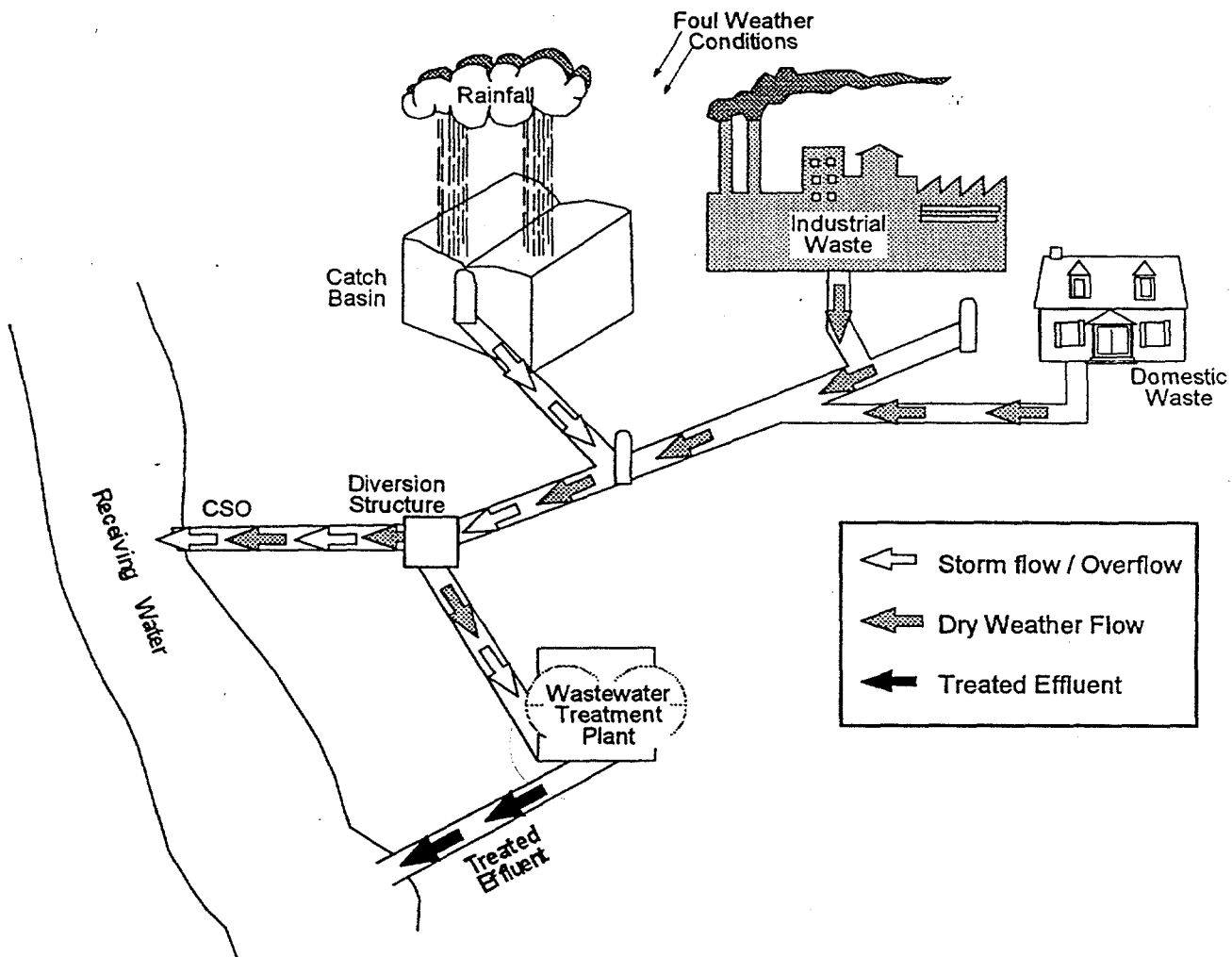


Figure 2-7. Typical Combined Sewer Collection Network

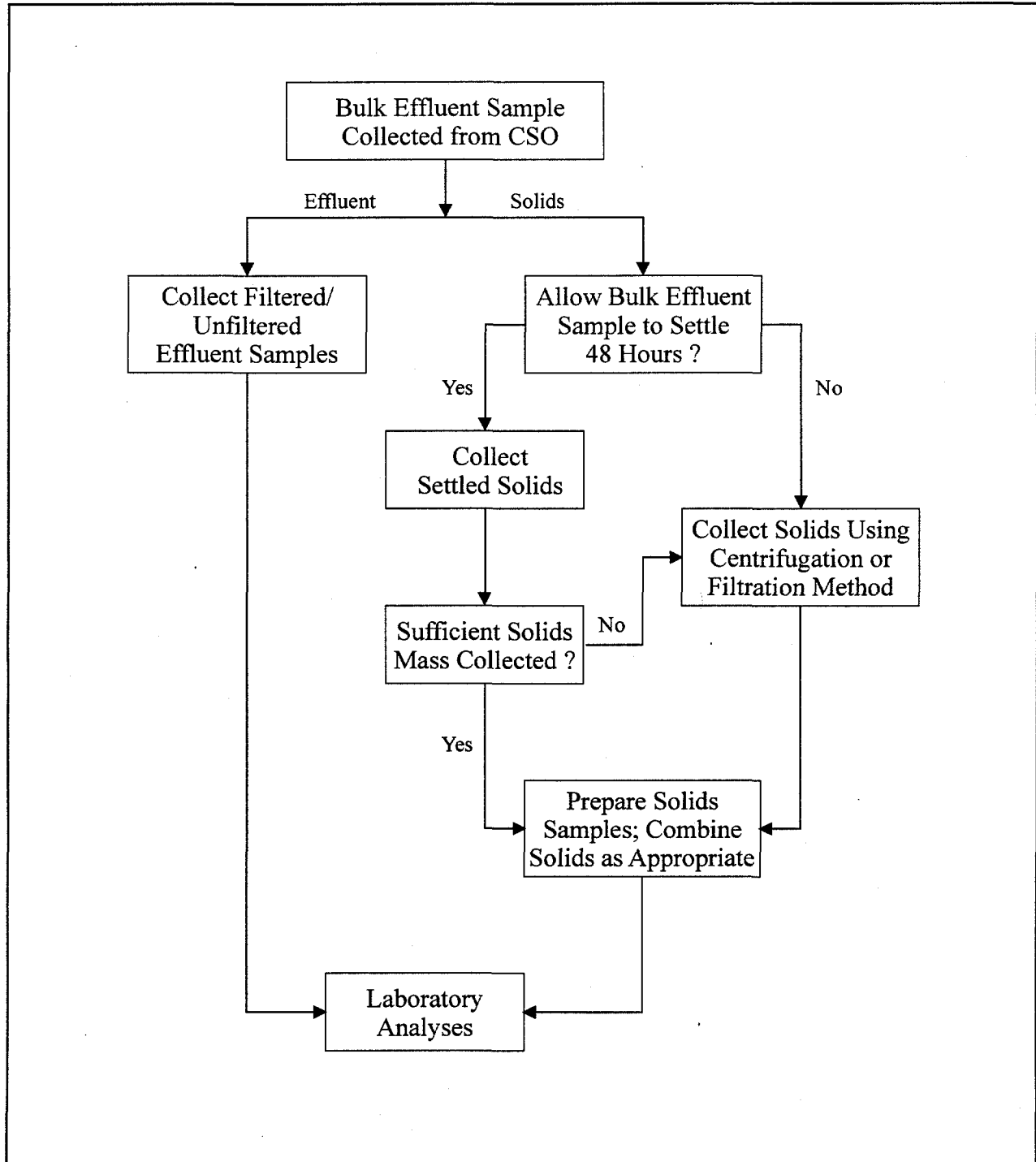


Figure 3-1. Collection Scheme for CSO Sampling and Analysis.

SOP 6

82697027

**ECOLOGICAL SAMPLING PLAN FOR THE
PASSAIC RIVER STUDY AREA**

STANDARD OPERATING PROCEDURE NO. 6

COMBINED SEWER OVERFLOW SAMPLING

BULK SAMPLING METHODOLOGY

December 2000

TABLE OF CONTENTS

Section	Page
1.0 APPLICABILITY	3
2.0 PREPARATIONS FOR SAMPLING	3
3.0 FIELD EQUIPMENT LIST	3
4.0 DECONTAMINATION OF EQUIPMENT	5
5.0 LOCATION OF SAMPLING STATIONS	5
5.1 CSO Locations	5
5.2 Precipitation/Tidal Monitoring	5
6.0 CSO SAMPLE COLLECTION AND PREPARATION	5
6.1 Semi-Automated Bulk Sampling Procedures	6
6.2 Manual Bulk Sampling Procedures	8
6.3 CSO Aqueous Sample Preparation	10
6.4 CSO "Settleable" Solids Preparation	11
6.5 CSO Solids Collection by Centrifugation/Filtration	13
6.5.1 Centrifugation Methodology	13
6.5.2 Filtration Methodology	16
7.0 SAMPLE CONTAINERS, PRESERVATION, HANDLING AND TRACKING	18
8.0 QUALITY CONTROL SAMPLES	18

1.0 APPLICABILITY

This Standard Operating Procedure (SOP) defines the primary methodology to be followed for the collection and preparation of combined sewer overflow (CSO) effluent and solids samples from the Passaic River Study Area (Study Area). These bulk sampling procedures give descriptions of equipment and field procedures necessary to collect CSO samples in this manner. SOP-14 (In-line Sediment Trap Sampling) provides a secondary method for collection of CSO solids.

Other SOPs that will be utilized with this procedure include:

- SOP No. 1 - Decontamination
- SOP No. 2 - Containers, Preservation, Handling and Tracking of Sample
- SOP No. 5 - Surface Water Quality Physicochemical Parameters (where appropriate)

2.0 PREPARATIONS FOR SAMPLING

The FSP identifies the process for the selection of CSO sampling stations, the frequency of sampling, sample type, field measurements, and analytical procedures for this study element. The field team is responsible for reviewing the FSP prior to conducting field activities and ensuring that all field equipment, including sample containers and preservatives, are available and in acceptable condition.

3.0 FIELD EQUIPMENT LIST

Equipment to be used during the collection of CSO effluent samples may include, but is not limited to, the following:

- Flow meter and electronic depth sensor, temperature/pH meter, and dissolved oxygen/conductivity meter
- Modem system for remote notification from CSO
- Backup temperature/pH meter, and dissolved oxygen/conductivity meter
- Field monitoring equipment (OVA or HNu, and CGI/O₂ meter)
- Submersible pump and tubing (stainless steel/Teflon) for collection of bulk water from CSO
- Sample collection containers
- Preservatives (as required)
- Trailer/mobile sampling unit
- Electronic controls for mobile sampling unit
- Trailer-mounted polyethylene bulk water holding tank(s) (minimum 600-gallon capacity)
- Electric generator (mounted on trailer)
- Wet Ice
- Insulated coolers
- Sample identification labels
- Tape
- Waterproof marking pens
- Sealable plastic bags and bubble wrap
- Litmus test strips for confirming proper sample preservation
- Traffic control equipment
- Westfalia Centrifuge (modified by Machine All, Inc., Ontario, Canada) (or equivalent)
- Filtration apparatus
- Pump for filtration/centrifugation (stainless steel/Teflon)
- Heavy duty/industrial power mixer [stainless steel/Teflon; appropriate size for mixing bulk water storage tank(s)]

- Automated precipitation gauge

4.0 DECONTAMINATION OF EQUIPMENT

Decontamination of CSO sampling equipment will be performed prior to the initial set-up and between each sampling event at each location in accordance with procedures outlined in SOP No. 1 - Decontamination. Personnel decontamination procedures are contained in the HASP.

5.0 LOCATION OF SAMPLING STATIONS

5.1 CSO LOCATIONS

The selection process of the CSOs to be sampled is described in the FSP. Once on location, the manhole access where the samples will be collected will be established and labeled on a map.

5.2 PRECIPITATION/TIDAL MONITORING

Automated monitoring equipment will be used to obtain precipitation data throughout the sampling program. Precipitation data will be obtained at a minimum of one location in the Newark area. In addition, tidal information from government sources will also be obtained during the entire sampling program.

6.0 CSO SAMPLE COLLECTION AND PREPARATION

Based upon the current knowledge of the CSO system (obtained via the Trial Run Program), the following procedure shall be implemented, as practicable, for collecting CSO samples from operable and accessible CSOs that discharge into the Study Area. The analytical sample volume requirements for the aqueous effluent samples and the solids samples are provided in Tables 4-1 and 4-2 of the QAPP, respectively, as well as Table 2-5 of this document (solids

only). Table 4-2 of the QAPP has been modified to include revised minimum sample dry weights, and is included as Attachment 2. Samples will be preserved in the field (described below).

For the Full-Scale CSO Program, water will be obtained from each CSO utilizing a semi-automated bulk sampling methodology (Section 6.1). Manual bulk sampling procedures (Section 6.2) will be used as an alternate water collection methodology should the semi-automated procedures prove infeasible at a particular CSO.

6.1 Semi-Automated Sampling Procedure

The semi-automated sampling procedure will utilize a mobile sampling unit for the collection of bulk CSO effluent water. This unit will utilize a heavy-duty enclosed trailer as a secure platform for mounting/housing the sampling equipment/controls. Within the enclosed trailer, electronic controls, polyethylene tank(s), power source, and appropriate tubing will be mounted/installed. A modem system will also be installed for remote notification of the overflow event.

At locations where traffic conditions/parking are not of concern, the sampling trailer will be placed directly adjacent to the manhole accessing the CSO. At locations where traffic conditions hinder the positioning of the trailer directly adjacent to the manhole, underground piping will be installed from an adjacent parking location. As appropriate, all necessary permits will be obtained from the local police, transportation, and sewerage/sanitation departments prior to sampling or accessing each CSO.

Traffic control may be needed to facilitate collection of the bulk sample. If the CSO location is heavily trafficked, a traffic control crew may be necessary. A local contractor experienced in traffic control would be retained to perform traffic control in accordance with New Jersey Department of Transportation regulations. The contractor would prepare a traffic control plan outlining notification procedures, crew training, and traffic control measures to be used in this

work. Passaic Valley Sewerage Commission (PVSC) traffic control protocols will be reviewed and incorporated, as appropriate.

The following protocols will be implemented at CSOs where traffic/parking is not an issue:

1. Properly decontaminate all sampling equipment to be used under this protocol, in accordance with SOP No. 1 – Decontamination.
2. Install flow meter, temperature/pH, depth, and DO/conductivity sensors at appropriate locations within the CSO. (Sensors should be programmed to obtain measurements at a minimum of fifteen minute intervals.)
3. Install pump at appropriate location within the CSO and connect tubing between pump and collection tank.
4. Install/hook up appropriate electrical controls for unmanned operation of the sampling unit.
5. Test equipment/sensors for proper operation, and ready equipment for bulk sample collection of overflow event.
6. Mobilize the sampling unit to the CSO and park it at a location in accordance with appropriate transportation/police department permits. Establish required traffic control. Coordinate with local police department, as required.
7. Initiate modem system for notification of sampling.
8. Secure sampling unit and manhole for unmanned operation. Coordinate periodic security/maintenance checks on sampling unit.
9. Upon notification of overflow by the modem system, return to the CSO during overflow or at completion of overflow. Determine if a complete (minimum 600 gallon) bulk sample has been collected. If a complete bulk sample has been collected, demobilize sampling unit. If a complete bulk sample has not been collected, notify the project field manager to determine the appropriate course of action.

The remaining tasks (10 through 12) assume collection of a complete bulk sample.

10. Transport the bulk water storage tank(s) to the sample processing facility.
11. Collect effluent and solids samples as outlined in Sections 6.3 through 6.5.
12. Decontaminate sampling equipment as appropriate. Ready unit for future sampling deployment.

The following additional preparation tasks will be implemented at CSOs where traffic/parking is an issue for set-up of the sampling trailer:

1. Obtain required permits from the local police, transportation, and sewerage/sanitation departments for roadcutting, installation of piping, and traffic control.
2. Coordinate roadcutting, pipe/wiring installation, backfill, and road resurfacing from CSO to the proposed mobile sampling unit location.
3. Mobilize sampling unit to location and follow the protocols outlined above.
4. Upon demobilization, piping is to remain beneath the road, unless the local municipality deems it necessary to remove.

6.2 Manual Bulk Sampling Procedure

This alternative manual procedure may be utilized if the semi-automated methodology is not feasible at a given CSO, or if there is pump or other system failure of the semi-automated unit.

1. Install flow meter, temperature/pH, depth, and DO/conductivity sensors at appropriate locations within the CSO (sensors should be programmed to obtain measurements at a minimum of 15 minute intervals). Submersible pump also may be mounted at this time, or alternately, installed upon sampling mobilization.

2. Monitor local weather conditions, and upon prediction of significant precipitation which would likely cause overflow, mobilize appropriate personnel and equipment to the CSO.
3. Remove manhole cover and perform appropriate health and safety checks.
4. Observe flow conditions. If overflow is occurring or likely to occur, continue with the following procedures. If overflow is not occurring, and is likely not to occur, notify the field project manager to determine the appropriate course of action.
5. Initiate flow and depth measurement at the first indication of overflow. Measure and record this information at a minimum of every 15 minutes during sample collection.
6. Measure and record temperature, dissolved oxygen, conductivity, and pH in the discharging water from the CSO pipe in accordance with SOP No. 5 - Surface Water Physicochemical Parameters. These measurements can be made directly from the pipe or a grab sample. The frequency of these measurements should be a minimum of every fifteen minutes unless field conditions limit the field teams' ability to sample at that frequency.
7. Set the submersible pump (if not installed previously) in the water column of the CSO pipe to initiate sample collection with the first flush and continue to sample until a minimum of 600 gallons of water has been collected, or the overflow event is over.
8. Transport the bulk water storage tank(s) to the staging area. Collect aqueous effluent and solids samples for chemical analyses following the procedures outlined in Sections 6.3 through 6.5.

6.3 CSO Aqueous Sample Preparation

Upon arrival at the staging area, the CSO effluent samples will be collected and prepared for shipment to the analytical laboratory(s). Both unfiltered and field filtered samples will be collected for analysis. The procedure for this sample collection is outlined below.

1. Homogenize the effluent sample in the bulk water storage tank(s) using the power mixer.
2. Collect the unfiltered aqueous samples from the bulk water storage tank(s) using a decontaminated beaker, bailer, or other sampling equipment.
3. Transfer to the appropriate laboratory sample containers by gently pouring the collected sample into the appropriate containers by allowing the sample to flow slowly down the interior of the laboratory sample containers.
4. Add preservative to laboratory sample containers as specified in Table 4-1 of QAPP.
5. Label the sample containers with the appropriate pre-printed sample identification labels.
6. Close and seal each container. Proceed with Step No. 8 for the unfiltered samples.
7. To obtain the filtered aqueous samples, pump the bulk effluent water through a 0.45 micron glass fiber filter(s). Transfer the filtrate into the appropriate laboratory sample containers and label with the appropriate pre-printed sample identification labels. Discard the filters.

8. Check label on each sample container and cover the label with clear plastic tape.
9. Wrap sample containers in bubble wrap and place in a sealable plastic bag. Place bag in refrigerator until sample is ready for packing and shipping.
10. Complete the appropriate chain-of-custody and sample delivery group (SDG) forms for each sample container, and seal in plastic bag.
11. Pack samples in shipping cooler with ice. Tape completed chain-of-custody and SDG forms on the inside of the lid of the shipping cooler and seal cooler with tape and custody seals. Ship within 24 hours of collection by overnight courier to the appropriate laboratory.

6.4 CSO "Settleable" Solids Preparation

The procedures in this section will be used to collect settled solids. If a determination has been made not to collect settled solids, proceed to Section 6.5 for collection of solids by centrifugation or filtration.

1. After collection of the CSO effluent samples, allow the suspended solids to settle in the bulk water storage tank(s) undisturbed for up to 48 hours.
2. If a sufficient amount of solids has settled after the 48-hour period, collect settled solids from bottom of tank(s) using appropriate collection equipment. If a sufficient amount of solids has not settled, proceed to Section 6.5 for collection of solids by centrifugation or filtration.

3. Transfer solids to a decontaminated tared glass or stainless steel container and weigh on an electronic balance capable of weighing to the nearest 0.1g. Remove any non-sediment debris, weigh and determine whether sufficient mass has been collected, as required in Table 2-5 of the FSP. Continue removing settled solids from composite tank until the target mass has been reached. Homogenize the solids.
4. If sufficient mass has been collected, transfer the settled solids to the appropriately labeled containers. Close and seal each container. A determination will be made by the field project manager as to whether additional solids will be collected using centrifugation or filtration methods (Section 6.5).

If sufficient mass has not been collected, transfer collected settled solids into appropriately labeled containers. Proceed to Section 6.5 for collection of additional solids using centrifugation/filtration procedures. Settled solids will be composited with solids collected using centrifugation methods, or combined as appropriate, with collected filters.

5. Check the label on each sample container and cover the label with clear plastic tape.
6. Wrap sample containers in bubble wrap and place in a sealable plastic bag. Place bag in refrigerator until sample is ready for packing and shipping.
7. Complete the appropriate chain-of-custody and SDG forms for each sample container, and seal in plastic bag.
8. Pack samples in shipping cooler with wet ice. Tape completed chain-of-custody form on the inside of the lid of the shipping cooler and seal cooler with

tape and custody seals. Ship within 24 hours of collection by overnight courier to the appropriate laboratory.

6.5 CSO Solids Collection by Centrifugation/Filtration

If an adequate quantity of solids are not collected via settling, or if a determination has been made to collect solids without waiting for settling to occur, additional solids will be obtained from the CSO effluent using either centrifugation or filtration methodologies. The centrifugation methodology will be the preferred methodology, if feasible. This methodology proved successful for solids collection during testing in May 2000, as discussed in a September 2000 letter from CLH to EPA (Attachment 4). [Note that this letter referenced and included SOP 6, which has been superseded by this December 2000 submittal.] Solids collection protocols for both methodologies are detailed below.

6.5.1 Centrifugation Methodology

1. Mix CSO effluent in bulk water storage tank(s) with power mixer; continue mixing throughout centrifugation process.
2. Transfer the appropriate volume of homogenized CSO effluent to the TSS and TOC sample containers. Add preservatives to the TOC container, label, and seal. Place in refrigerator or cooler until ready for shipment.
3. Label the appropriate sample containers with the pre-printed sample identification labels.
4. Decontaminate the centrifuge bowl components in accordance with the procedures outlined in SOP No. 1 - Decontamination.

5. Reassemble the centrifuge bowl components and reattach to the centrifuge in accordance with the Machine All (or equivalent) operation manual.
6. Place the submersible pump in the bulk water storage tank. Do not connect the pump to the centrifuge.
7. Position the outlet hose such that it will discharge back into the holding tank. Start the pump and adjust the valve on the water line to achieve a flow rate of 1-2 liters per minute. Turn the pump off and secure the outlet hose to the centrifuge.
8. Start the centrifuge and wait until the centrifuge is up to speed. When the centrifuge is at speed, turn the pump on and watch for the water to exit the drain pipe. The back-pressure valve should be adjusted so that there are no bubbles in the sight glass on the discharge pipe.
9. Record the flow rate every 10 - 15 minutes and adjust as required.
10. At the completion of each centrifugation run [approximately 2 hours of operation or approximately 240 liters (60 gallons) at a 2 liter/minute flow rate], turn off the pump and disconnect the outlet hose from the centrifuge. After all water has stopped flowing from the centrifuge discharge pipe, turn the centrifuge off.
11. Remove the centrifuge bowl pump and, without taking the bowl apart, drain off all remaining water from the bowl into a decontaminated squeeze bottle, with excess water stored in a decontaminated sample bottle. This water will be used to (1) rinse material from the bowl assembly and (2) provide additional material, if needed, by drying.

12. Disassemble the bowl, placing each section inside the other so as not to cause any contamination.
13. Clean each section starting with the innermost triangular section and work outward. Use a Teflon spatula to remove solids from the bowl surfaces into a decontaminated stainless steel or glass container. After loosening the material with a brush and spatula, use the squeeze bottle to sparingly wash each section into a separate decontaminated container. After all sections have been cleaned, pour all of the water captured from the bowl and squeeze bottle into a sample container.
14. Weigh the collected solids/sample container to determine whether sufficient mass has been collected, as required in Table 2-5 of the FSP. Continue centrifugation until the target mass has been reached.
15. When sufficient mass has been collected, homogenize and transfer the collected solids to the appropriately labeled containers. Close and seal each container. If, at the conclusion of centrifugation of a minimum of 600 gallons, insufficient mass has been collected, prepare additional sample containers with the retained rinse water to be submitted to the laboratories for drying.
16. Check the label on each sample container and cover the label with clear plastic tape.
17. Label, pack, and ship samples according to SOP No. 2.

6.5.2 Filtration Methodology

1. Mix CSO effluent in the bulk water storage tank with power mixer; continue mixing throughout filtering process.
2. Transfer the appropriate volume of homogenized CSO effluent to the TSS and TOC sample containers. Add preservatives to the TOC container, label, and seal. Place in refrigerator or cooler until ready for shipment.
3. Label the appropriate sample containers with the pre-printed sample identification labels.
4. Place the decontaminated 1.2 μm filter(s) in the filtering apparatus. Start the pump (stainless steel/Teflon) and add an appropriate volume of homogenized effluent sample.
5. Continue to add effluent sample until the filtrate container is full, or the filtering time slows, whichever comes first. Carefully remove the filter(s) with forceps and place on a decontaminated glass plate. Retain 50-mL of filtrate for apparatus rinse, and decant the remaining filtrate into a container for subsequent disposal. Add new filter(s) and resume filtration.
6. If the filtering process is slow, or visual inspection of the effluent suggests that there is a large concentration of suspended solids, sequential filtration may be required. In this case, the effluent is initially passed through the 10 μm filter(s), followed by filtering with the 1.2 μm filter(s).

7. Rinse the filtering apparatus with the retained filtrate to ensure that all of the solids have been removed from the sides of the filter holder.
8. Remove any non-sediment debris, weigh and determine whether sufficient mass is collected as required in Table 2-5 of the FSP. Continue filtering until the target mass/number of filters have been collected.
9. Stack used filters and place in appropriately labeled containers. Close and seal each container.
10. Check the label on each sample container and cover the label with clear plastic tape.
11. Wrap sample containers in bubble wrap and place in a sealable plastic bag. Place bag in refrigerator until sample is ready for packing and shipping.
12. Complete the appropriate chain-of-custody form for each sample container, and seal in plastic bag.
13. Pack samples in shipping cooler with ice. Tape completed chain-of-custody form on the inside of the lid of the shipping cooler and seal cooler with tape and custody seals. Ship within 24 hours of collection by overnight courier to the appropriate laboratory.

7.0 SAMPLE CONTAINERS, PRESERVATION, HANDLING AND TRACKING

Sample containers, handling and preservation procedures are described in SOP No. 2 - Containers, Preservation, Handling and Tracking of Samples for Analysis.

8.0 QUALITY CONTROL SAMPLES

To identify potential sources of sample contamination and evaluate potential error introduced by sample collection and handling, field quality control samples (QC samples) will be collected during the CSO sample collection. All QC samples will be labeled in accordance with SOP No. 2 - Containers, Preservation, Handling and Tracking of Samples, and sent to the laboratory with the other samples for analysis. QC samples for CSO sampling will include rinsate samples, field duplicate samples, and matrix spike samples and will be collected at the frequency identified in the QAPP.

SOP 14

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**ECOLOGICAL SAMPLING PLAN FOR THE
PASSAIC RIVER STUDY AREA**

STANDARD OPERATING PROCEDURE NO. 14

COMBINED SEWER OVERFLOW SAMPLING

IN-LINE SEDIMENT TRAP METHODOLOGY

December 2000

TABLE OF CONTENTS

<u>Section</u>	<u>Page</u>
1.0 APPLICABILITY	4
2.0 FIELD EQUIPMENT LIST	4
3.0 DECONTAMINATION OF EQUIPMENT	6
4.0 EQUIPMENT	6
4.1 Trap Design and Fabrication	6
4.2 TSS Sampling Equipment	8
4.3 Flow Measurement Equipment	8
4.4 Precipitation/Tidal Monitoring	9
5.0 SAMPLING LOCATIONS	9
6.0 TRAFFIC CONTROL	10
7.0 MONITORING AND SAMPLING EQUIPMENT INSTALLATION,	11
INSPECTION, AND RETRIEVAL	
7.1 Sediment Trap	11
7.2 Flow Measurement and TSS Sampling Equipment	15
8.0 COLLECTION OF "SUPPLEMENTAL SEDIMENTS" FROM CATCH BASINS	18

TABLE OF CONTENTS (Continued)

<u>Section</u>	<u>Page</u>
9.0 SAMPLE PROCESSING	19
9.1 Sediment Sample	19
9.2 Storm Water Sample	20
10.0 SAMPLE CONTAINERS, PRESERVATION, HANDLING, AND TRACKING	20
11.0 QUALITY CONTROL SAMPLES	20
12.0 REFERENCES	21

FIGURES

Figure 1 Sediment Trap Design.....	22
Figure 2 Sediment Trap Dimensions.....	23
Figure 3 Typical Monitoring Location of Sediment Trap	24
Figure 4 Sampling and Monitoring Equipment Placement in a Sewer System	25

1.0 APPLICABILITY

This Standard Operating Procedure (SOP) summarizes the design and defines procedures for fabrication, installation, and retrieval of *in-line* sediment traps to be used to collect samples from CSO outfalls in the Passaic River Study Area (Study Area). These procedures describe the equipment and field procedures necessary to locate, install, and retrieve the traps.

Other SOPs and documents that will be utilized with this procedure include:

- SOP No. 1 - Decontamination
- SOP No. 2 - Containers, Preservation, Handling, and Tracking of Samples for Analysis
- SOP No. 6 - Bulk Sampling Methodology

2.0 FIELD EQUIPMENT LIST

Equipment to be used during the installation of traps may include, but is not limited to, the following:

- Sediment traps with mounting equipment for each location (procure sufficient materials for a minimum of 4 traps per CSO plus replacement units).
- Tool to manipulate vault cover
- Rotary hammer
- 220-volt generator with ground fault interrupter
- Ratchet with extension
- (12) 10- to 12-inch bits
- Standard hammer
- (8 per trap) 0.25-inch-diameter, 2.5- to 3-inch-long thunder bolts
- (8 per trap) 0.25-inch lock nuts

- (8 per trap) 0.25-inch washers
- (10) 0.25-inch-diameter, 0.5- to 1-inch-long nuts
- Blower to evacuate confined space
- Tripod with personnel basket and hoist
- 5-gallon plastic buckets and rope
- Spotlight.
- Automated sampler with integral flow meter (area/velocity probe).
- Field monitoring equipment (OVA or Hnu, and CGI/O₂ meter).

Equipment to be used during the retrieval of traps and subsequent sampling may include, but is not limited to, the following:

- Tool to manipulate vault cover
- 220-volt generator with ground fault interrupter
- Ratchet with extension
- Saw
- Rotary hammer
- Standard hammer
- Blower to evacuate confined space
- Field monitoring equipment (OVA or Hnu, and CGI/O₂ meter).
- Tripod with personnel basket and hoist
- 5-gallon plastic buckets and rope
- Spotlight
- Appropriately sized sample containers
- Tape
- Sealable plastic bags

- Waterproof marking pens
- Camera
- Peristaltic pump
- Stainless steel homogenization bowl and utensils
- Stainless steel or disposable scoop.

Equipment to be used to control traffic (when applicable) during installation and retrieval may include, but is not limited to, the following:

- Cones
- Flaggers with hardhats
- Vests for all workers
- Slow/stop paddle
- Signage
- Vehicle with lights to direct traffic

3.0 DECONTAMINATION OF EQUIPMENT

Decontamination of the traps will be performed prior to deployment and after retrieval in accordance with procedures outlined in SOP No. 1 - Decontamination. Personnel decontamination procedures are contained in the HASP.

4.0 EQUIPMENT

4.1 TRAP DESIGN AND FABRICATION

The design consists of four main components, including a glass bottle with screw closure, stainless steel cup, mounting bracket, and an adjustable arm connecting the cup and mounting bracket. Components other than the cup will be fabricated from flat 1/8-inch-thick weldable

stainless steel. The cup will be fabricated from standard 1/8-inch-thick weldable stainless tubing with a 4-inch outer diameter. A slot running lengthwise down the cylinder allows flushing of the space between the bottle and the cup during the monitoring period. Figures 1 and 2 illustrate the design.

During a Tacoma, Washington study, each sediment trap typically was found to collect between 50 and 100 g of sediments (dry weight) over a period of 128 days with 26.9 inches of rainfall. During the CSO Trial Run Program, the sediment traps were found to capture approximately 2 to 4 inches of sediment over a 45-day period.

The collected sample mass is a function of rainfall, suspended solids concentration in stormwater, sediment bulk density, particle size distribution, and hydraulic/flow characteristics of the CSO. The mass collected can be increased as follows:

- Increase collection duration
- Increase number of traps at each location
- Modify the trap design.

The latter option, modifying trap design, may involve selecting a bottle with a larger mouth to increase the collection area (such as Fleakers™ bottles sold by Cole-Parmer). However, an opening too large could increase turbulence and re-suspension within the bottle, resulting in a smaller sample. A larger collection vessel could also be considered but it may disturb storm water flow and is more likely to be dislodged and broken during large storm events.

The analyses are prioritized so that the most critical analyses are performed when insufficient volume is collected (see Table 2-5 of the ESP).

The CSO Trial Run demonstrated that traps mounted in the center of the CSO chamber were generally found to collect more solids than traps located near the sides of the chamber, or near the stop logs/tide gates. This finding may not be consistent across all CSOs due to the structural variation between CSOs. As such, sediment trap installation locations will be determined on a case by case basis.

4.2 TSS SAMPLING EQUIPMENT

TSS concentrations are necessary, in conjunction with flow rates and sediment analytical data, to estimate the contaminant loads to the river. To measure TSS, an automated sampler will be installed in the vault or pipe and programmed to activate upon an overflow event. The sampler will collect a flow-proportional composite water sample over the storm event period. The portable sampler is battery-operated and will not keep the sample refrigerated. Therefore, sample retrieval must be performed as soon as possible after the storm event. Because of adverse operating conditions in the drainpipe, the sampler will be serviced every two weeks or after each storm event along with the flow meter. Equipment maintenance is presented in Section 7.0 of this SOP.

Automated portable samplers are supplied by Isco, American Sigma, Manning, Marsh McBirney, and Buhler Montec among others. When selecting a model, verify its compatibility with the flow meter, its ruggedness, battery life, and sample size.

4.3 FLOW MEASUREMENT EQUIPMENT

Flow data will be collected continuously during trap deployment at each monitoring location. A portable, battery-powered flow meter will be installed at the monitoring point to log stormwater flow.

Flow measurement can be performed with a portable bubble line system or a sonic-transducer probe system. The latter is typically more accurate. The pipe configuration must be programmed into the flow meter to allow flow calculation. Portable flow meters are supplied by Isco, American Sigma, Manning, Marsh McBirney, and Buhler Montec among others. When selecting a model, verify its compatibility with the flow meter, its ruggedness, and battery life. Because of adverse operating conditions in the drainpipe, the flow meter should be serviced frequently. Battery life varies between a week and two months depending on the data-logging rate. In addition, flooding may damage the electronic components and dislodge or wash down the equipment. Equipment maintenance is presented in Section 7.0 of this SOP.

4.4 PRECIPITATION/TIDAL MONITORING

Automated monitoring equipment will be used to obtain precipitation data throughout the sampling program. Precipitation data will be obtained at a minimum of one location in the Newark area. In addition, tidal information from government sources will also be obtained for the period of trap deployment.

5.0 SAMPLING LOCATIONS

Trap installation locations will be selected in coordination with PVSC personnel. Whenever possible, the traps will be installed near the bottom of junction boxes or catch basins (vaults). Otherwise, the traps will be mounted near the occurrence of turbulent eddies within a pipe. Figure 3 is an illustration of typical trap locations within a junction box. Installing a minimum of four traps (where feasible) will increase the likelihood of collecting a sufficient volume of sediment. The following are general logistical suggestions for selecting locations:

- If installing directly in pipes, the inner diameter should be no less than 36 inches to prevent significant blockage.
- Avoid offset pipes where debris may fall onto the trap.
- Install at lowest practical point at location.
- Avoid locations contributed to by unscreened ditches or drains which may carry large debris.
- Locate above back flooding from river, if feasible.

Sampling locations will be selected strategically in areas (if practicable) that are not impacted by tidal water from the Study Area, on the basis of existing river level data, drainage patterns, and drain layouts. Due to the widely varied CSO configurations, trap locations will be determined on a case-by-case basis. Once determined, the trap locations will be labeled on a schematic of the CSO.

6.0 TRAFFIC CONTROL

Traffic control may be needed to facilitate trap installation and retrieval. If the locations selected are heavily trafficked, a traffic control crew may be necessary. A local contractor experienced in traffic control would be retained to perform traffic control in accordance with New Jersey Department of Transportation regulations. The contractor would prepare a traffic control plan outlining notification procedures, crew training, and traffic control measures to be used in this work. PVSC traffic control protocols will be reviewed and incorporated as appropriate.

7.0 MONITORING AND SAMPLING EQUIPMENT INSTALLATION, INSPECTION, AND RETRIEVAL

7.1 SEDIMENT TRAP

The following procedures shall be implemented, as practicable, for installing the sediment traps at selected vault locations (Naccarato, 1998). At least two personnel are necessary, including a worker and a confined space entry standby person/supervisor. Additional workers may be necessary inside the vault. Traffic control operators may be necessary. Health and Safety procedures associated with installation and removal are presented in the HASP. In addition, trap installation and retrieval will be coordinated with the PVSC. Information regarding the PVSC's protocols for entering manholes/vaults will be requested prior to trap installation. A minimum of four traps will be installed at each location to collect sediment. However, space limitations within individual CSOs may reduce this targeted number of installed traps.

1. Remove vault lid, using care not to stand over opening.
2. Complete confined space entry procedures and post valid entry permit.
3. Fix light in vault.
4. Secure worker to harness; worker climbs down (temporary) ladder into vault. (Note: Tripod and harness is not for entry or exit, except in emergency).

5. Lower bucket with roto hammer and attached bit, mounting bracket, lock nuts, thunderbolts, and washers. The thunderbolts should have their threads protected with 1-inch nuts affixed before lowered.
6. Punch first pilot hole with roto hammer. If using a battery operated roto hammer, care must be taken to avoid possibility of electric shock or electrocution.
7. Pound thunderbolt into pilot hole with standard hammer and remove protective nut.
8. Secure one corner of mounting bracket to the first thunderbolt with washer and lock nut.
9. Position mounting bracket as desired, punch remaining three pilot holes with bracket in place, pound in bolts, remove protective nuts, secure with washers and lock nuts.
10. Lower trap and ratchet with extension.
11. Attach trap to mounting bracket. Although it is preferable to position the trap at a 90 degree angle from the surface, the angle can be adjusted to accommodate low flows if necessary. Depending on flow or stagnant water level at the time of installation, water may fill the bottle during this step.

Bottles will be wrapped in tape to provide a snug fit into the bracket. In addition, the bottles will be wired to the bracket and filled with water once mounted (to reduce buoyancy).

12. Put remaining equipment and supplies in bucket and raise.

13. Worker(s) exits vault via (temporary) ladder.

14. Replace vault lid.

During the initial phase of the Full-Scale Program (when both SOPs 6 and 14 will be utilized concurrently), traps will be installed for a minimum of 30 days. If sediments traps are utilized as the primary collection method in later phases of the Full-Scale Program, traps will be left in place for up to 120 days.

Traps will be inspected periodically, and after each precipitation event, noting sediment depth and assessing the potential for wash-out. Any broken traps will be replaced. Any traps not collecting sufficient sample volumes may be repositioned to improve catch efficiency. If the trap jar is full at the time of an inspection, the sample will be retrieved in the manner described below. Otherwise, samples will be retrieved upon expiration of the monitoring period as follows:

1. Remove vault lid, using care not to stand over opening.
2. Complete confined space entry procedures and post valid entry permit.
3. Fix light in vault.
4. Secure worker to harness and tripod basket; worker climbs down (temporary) ladder into vault. (Note: Tripod harness is not for entry or exit, except in emergency).
5. Lower bucket with sample bottle cap, ratchet and attached extension, hammer (or saw).

6. Remove and seal sample bottle with cap.
7. Raise sample bottle, package, label, place on ice. Lower bucket.
8. Remove trap and mounting bracket and place in bucket.
9. Break with hammer or saw off protruding portion of bolts, leaving a flush surface.
10. Put remaining equipment and supplies in bucket and raise.
11. Worker exits vault via (temporary) ladder.
12. Replace vault lid.

Weather conditions will determine the precise time of installation and retrieval. Confined space operations and personnel decontamination are to be conducted in accordance with procedures outlined in the HASP. Decontamination of equipment will be performed after trap retrieval in accordance with SOP No. 1 - Decontamination.

7.2 FLOW MEASUREMENT AND TSS SAMPLING EQUIPMENT

Installation

To obtain flow measurements and collect TSS samples, utilize the following procedures (Thrush and DeLeon, 1993):

- Follow the same access procedures as described in Section 7.1.
- Find a level, smooth surface in the pipe with no disturbances in the immediate area on which to install the flow meter. With the probe system, the probe is usually placed facing upstream, mid-flow in the pipe as far from the sampler suction line as possible. The tubing for the bubbler line system should be placed midstream in the drainage pipe.
- Place the sampler suction line midstream in the pipe parallel to the flow. The line should not disturb the flow where it is measured by the flow meter. If improperly placed in the pipe, the sampler suction line will cause a slight disturbance in the flow pattern, thus interfering with the flow measurements.
- Use masonry anchors, screws, and tubing anchors to secure the bubbler or probe and suction line. A battery-powered drill with a masonry drill bit is required to drill the anchor holes. The lines must be anchored to prevent bending during high-velocity flows within the pipe. Placing an anchor approximately every 20 inches is recommended for pipes with high-velocity flows.
- Connect all power sources (batteries, direct sources) and turn the equipment on.

- Calibrate the volume of each individual sample on the sampler by collecting a manual sample and measuring its volume. Adjust the sample volume according to the sampler's operating manual.
- Calibrate the flow meter either in the office before installation or in the field after installation, depending on the type of equipment.
- Program equipment and check operation of the system.
- Connect the flow meter to the sampler with the flow meter connection cable and set flow meter and sampler on the shelf or hang them from the manhole ladder. Position the flow meter in the manhole to prevent water from entering the atmospheric reference port associated with the pressure transducer. Water entering this port can damage the flow meter electronics.
- Connect the suction line to the sampler at the pumphousing clamp. Place the sampler on a shelf in the manhole or hang the sampler from a rung on the manhole ladder. Put a decontaminated sample collection container in the sampler.
- Attach a safety line from the ladder rungs to the sampler and to the flow meter to prevent them from being washed down the drainpipe during high-velocity flows.
- When installation is complete, replace the cover on the manhole and remove the safety equipment and traffic controls.

A completely installed automatic flow-proportional composite system is illustrated on Figure 4.

Equipment Maintenance

Maintenance on the sampling system is required when the equipment is in place for extended periods of time or when sampling multiple storm events. Maintenance includes replacing the sampler and flow meter batteries, replacing damaged suction tubing, retrieving flow meter data, and refining the system programming. Because of the adverse operating conditions in the drain pipe and the need for equipment to function properly under these conditions, the equipment should be serviced every week or after each storm event.

Equipment maintenance should include the following steps:

- As appropriate, remove the sample container, rinse the suction line, and place a clean container in sampler.
- Retrieve the flow data from the flow meter and review the current readings to assess the condition of the battery and to check the recorded depth against the actual drain pipe depth.
- Adjust the equipment programming on the basis of the current flow meter information. Recalibrate the equipment according to the equipment manuals.
- Check the moisture content and working order of all equipment. Replace desiccant in the equipment electronic housing if necessary. Desiccant reduces the moisture buildup in the equipment.

After completion of data collection, remove all equipment following the same access and health and safety procedures as outlined for the sediment trap.

8.0 COLLECTION OF "SUPPLEMENTAL SEDIMENTS" FROM CATCH BASINS

It is possible that insufficient sample volume would be collected at some sampling locations using the sediment traps. An analytical hierarchical prioritization for analyses of CSO solids (ESP Table 2-5) was developed to prioritize chemical analyses in this event. In an effort to minimize the occurrence of insufficient sample volume, additional sediment will be collected from the accumulated sediments at the bottom of the catch basin or manhole, or in sediment trap installed by PVSC (if applicable). Only sediments which are similar to those collected in the sediment traps will be sampled. Non-representative materials such as refuse, debris, and coarse grain sediments will not be sampled. During survey of the manholes and catch basins and installation of the new sediment traps, the presence of PVSC installed sediment traps, or any sediment accumulation, will be documented to facilitate future sampling, as needed. Samples of accumulated sediments which are similar to those collected in the sediment traps will be collected (if necessary) with a decontaminated scoop. These sediments will be combined with the sediments collected in the sediment traps and processed as described in Section 9.0 of this SOP.

9.0 SAMPLE PROCESSING

9.1 SEDIMENT SAMPLE

Sample processing will begin in the field immediately after collection. The contents of all sample bottles will be homogenized and split using the procedure below.

1. Pump away any standing water from the surface of the jar(s) using a peristaltic pump. Discharge the water in the effluent pipe from the vault.
2. Photograph the jar(s).
3. Remove sediment from the jar(s) using appropriate decontaminated equipment (Teflon/stainless steel) and collect in a stainless steel bowl.
4. Add "supplemental sediment" (if applicable).
5. Homogenize the bulk sediment until the sediment appears uniform in color and texture.
6. Distribute the homogenized sediment to appropriate sample containers including quality control sample (QC sample) containers (Section 10.0) and label according to SOP No. 2 - Containers, Preservation, Handling, and Tracking of Samples for Analysis.

Once the samples are in their appropriate containers and labeled, they will be wrapped in bubble wrap, placed in a sealable plastic bag, and kept on ice until ready for shipping. Samples should

be shipped immediately after collection by overnight courier to the appropriate laboratory in accordance with SOP No. 2 - Containers, Preservation, Handling, and Tracking of Samples for Analysis.

9.2 STORM WATER SAMPLE

As soon as possible after a storm event, retrieve the storm water sample (for TSS analysis) using the same access and health and safety procedures as outlined under Section 7.0. Seal and label the sample container according to SOP No. 2 - Containers, Preservation, Handling, and Tracking of Samples for Analysis. Place a clean container in the sampler.

Once the samples are in their appropriate containers and labeled, they will be wrapped in bubble wrap, placed in a sealable plastic bag, and kept on ice until ready for shipping. Samples should be shipped immediately after collection by overnight courier to the appropriate laboratory in accordance with SOP No. 2 - Containers, Preservation, Handling, and Tracking of Samples for Analysis.

10.0 SAMPLE CONTAINERS, PRESERVATION, HANDLING, AND TRACKING

Sample containers and handling and preservation procedures are described in SOP No. 2 - Containers, Preservation, Handling, and Tracking of Samples for Analysis.

11.0 QUALITY CONTROL SAMPLES

To identify potential sources of sample contamination and evaluate potential error introduced by sample collection and handling, field quality control samples will be collected during the CSO sample collection (Section 8.0 Sample Processing) at locations with sufficient sample volume. The QC samples will be labeled in accordance with SOP No. 2 - Containers, Preservation,

Handling, and Tracking of Samples for Analysis, and sent to the laboratory with the other samples for analysis. QC samples for CSO sampling will include rinsate samples, field duplicate samples, and matrix spike samples and will be collected at the frequency identified in the Quality Assurance Project Plan (QAPP).

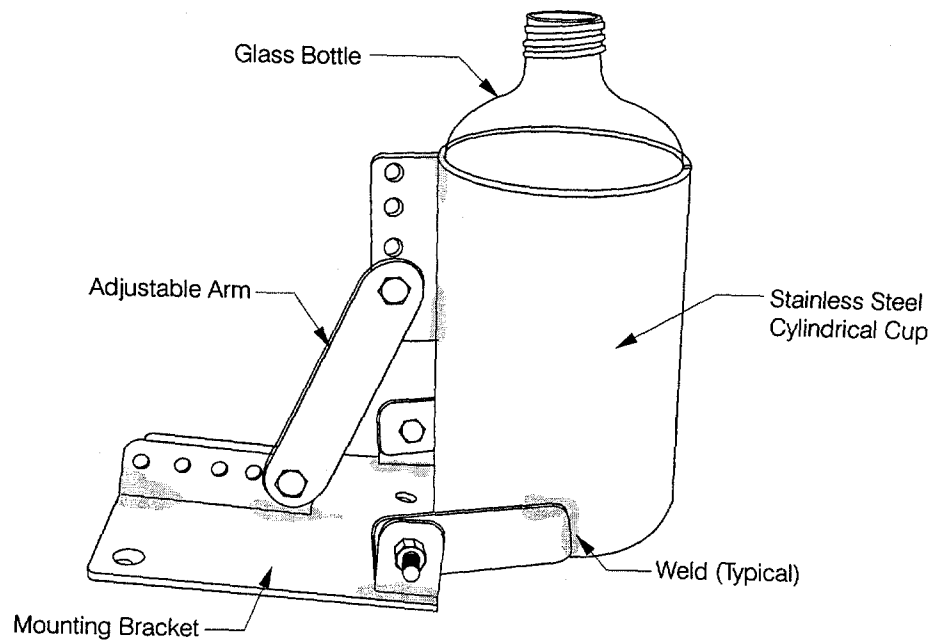
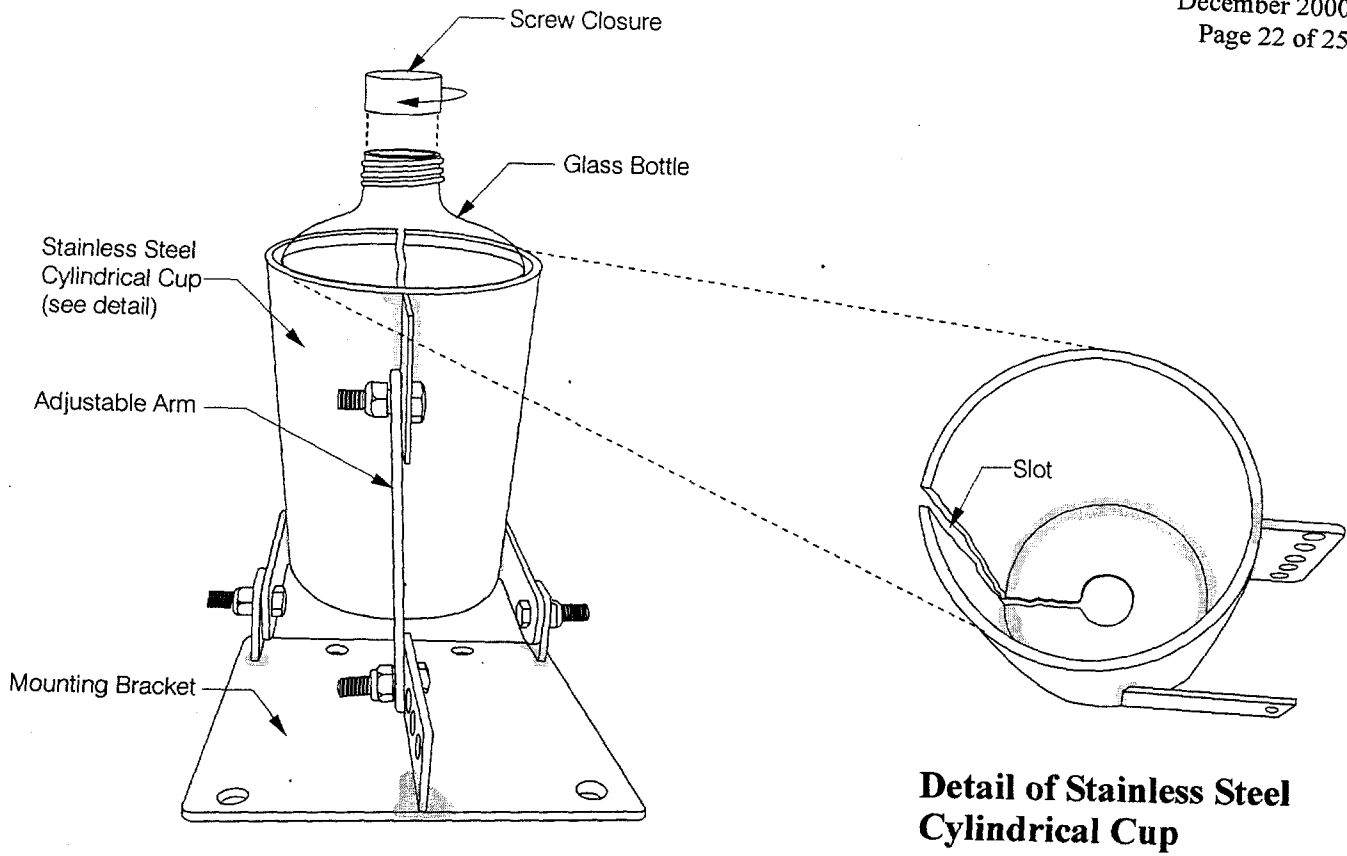
12.0 REFERENCES

Naccarato, Troy, 1998. Personal Communication, City of Tacoma, Source Control, August 1998.

Thrush, Cindy and Dana B. DeLeon, 1993. Automatic Stormwater Sampling Made Easy. Published by the Water Environment Federation, 1993.

Figure 1. Sediment Trap Design

FSP
Revision No. 5.0
SOP No. 14
December 2000
Page 22 of 25



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Figure 2. Sediment Trap Dimensions

FSP
Revision No. 5.0
SOP No. 14
December 2000
Page 23 of 25

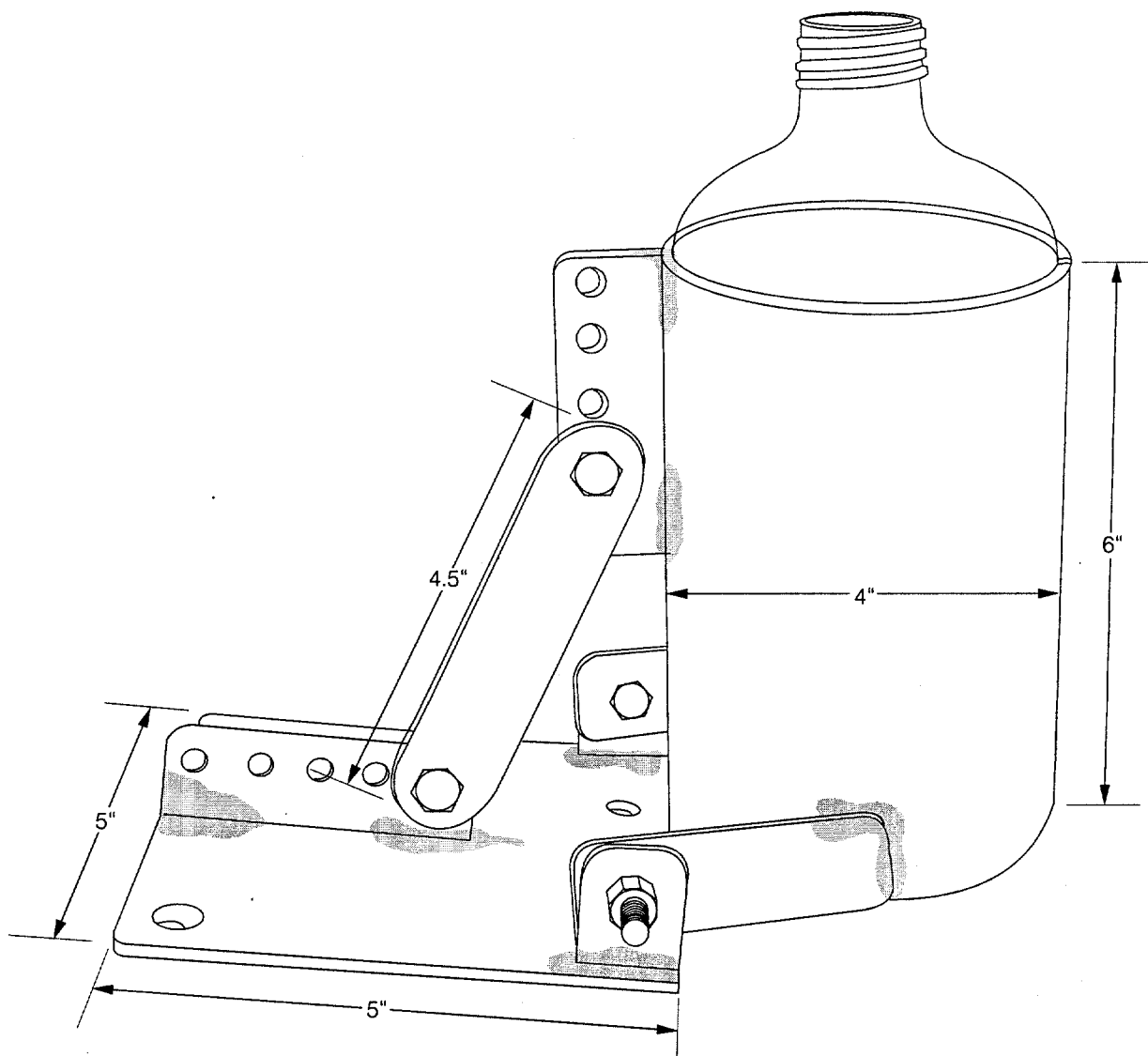


Figure 3. Typical Mounting Location of Sediment Trap

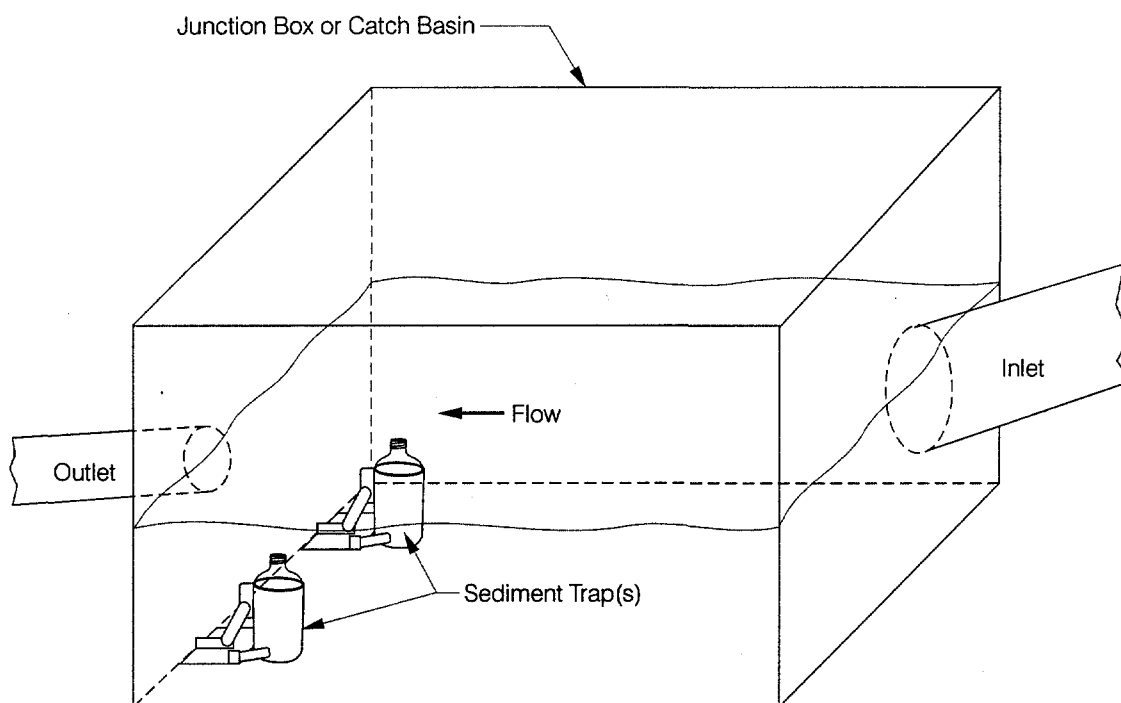
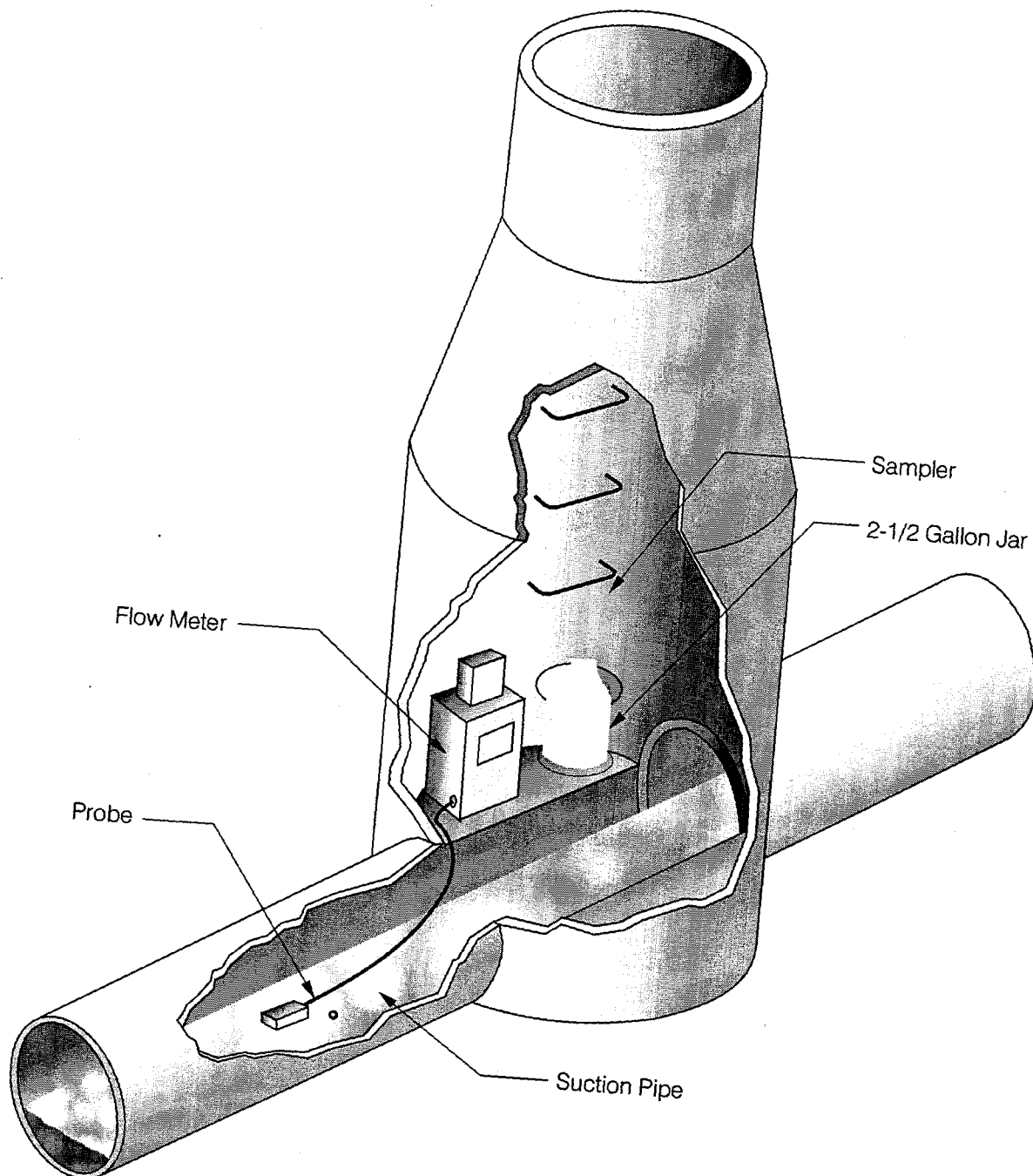


Figure 4. Sampling and Monitoring Equipment Placement in a Sewer System



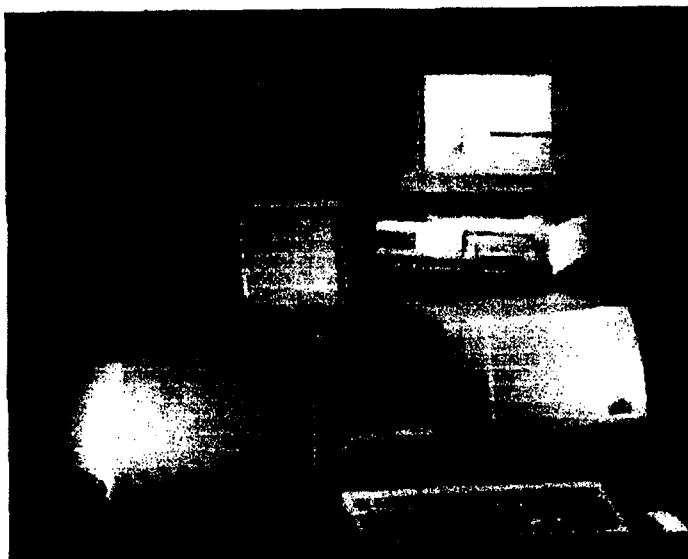
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Attachments

Attachment 1

Mastersizer S Particle Size Analyzer - Benchmark performance - proven reliability



If you want to be able to measure any of the diverse types of sample with which a typical R&D facility may be presented, or if you have samples with very broad particle size distributions, then the Mastersizer S is for you.

The wide dynamic range, 0.05 μ m to 3500 μ m; "smart optics"; advanced signal processing and unmatched accessory combinations make the Mastersizer S the most complete laser diffraction instrument available.

The expertise gained as Malvern pioneered laser diffraction technology has resulted in a detector array that ensures maximum response to all sizes of particle, even sub-micron, with the lowest level of noise. Response times are fast too, with the Mastersizer S recording each set of light scattering data in just 2 milliseconds.

All Mastersizer instrument systems and associated software have undergone a rigorous validation program to enable users to provide a complete audit trail to Regulatory Authorities both for their particle sizer installation and for their results. Ownership of a Mastersizer S connects you directly to the Malvern support network, including access to an applications library and laboratories around the world as well as the Malvern Help Desk.

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The Mastersizer S

The Measurement Principle

A diffraction particle sizer operates by observing the light scattered from particles as they pass through a safe low power visible laser beam. However particles are not sized individually and counted, instead the laser beam is large at the point of measurement and many thousands of particles are simultaneously illuminated.

The fraction of light scattered is the sum of all the individual particle contributions at any instant. The light signal is typically measured and integrated over time whilst the sample is flowed through the laser beam. By this means a scattering pattern is accumulated within a few seconds that is statistically representative of the bulk material.

This scattering pattern is the essential data that is analysed to produce a size distribution. The instrument understands how individual particles scatter light and holds within it the theoretical detector responses for each of its measurement size classes. It analyses the measured data and determines the volume contribution of each size class by fitting its theoretical scattering curves to the actual data. Once optimised it reports a Volume distribution whose scattering best matches the measurement. Mastersizer S includes the ability to transform this resultant distribution to Number, Length or Surface form for maximum user convenience.

The dynamic range of size measurement is intimately related to the range of scattering angles detected. The Mastersizer S series measures from 1/100th of a degree to 150 degrees, giving an overall size range capability of 0.05-3500µm. Resolution is fundamentally set by the nature of the scattering patterns and their rate of change with size. It is comparable with all other ensemble measurement techniques. Reproducibility is related to the precision of the light scattering measurement which is easily ensured. Typically better than 0.5%, this technique offered the highest repeatability of all size analysis methods in recent independent trials.

Particles may be dispersed in any transparent gaseous, liquid or solid "dispersant", ensuring no restrictions to special carrier fluids. The particles may also be of any phase, as long as they are optically distinct from the support medium so that they scatter light. Therefore the technique is eligible for measurement of liquid droplets, two phase fluids and gas bubbles as well as the more obvious application of solid particulates.

The technique has immediate practical attractions as a measurement method for industrial use. A huge dynamic range, fast measurement speed and high reproducibility are coupled to a wide range of particle and dispersant tolerance. Measurement times can be short and yet still give sta-

tistically representative measurements of the bulk material. Results are available within a few minutes, with sensitivity down to $0.05\mu\text{m}$. This means reliable and economic measurements applicable to a large family of materials.

Delivering the Benefits

Malvern has been the leading company promoting this technique since its inception in the late 1970's. The Mastersizer S series represents the most flexible instrument range on the market, fully exploiting the intrinsic measurement benefits of laser diffraction. It incorporates the widest range of sampling accessories available, all of which integrate so that switching from one to another is easy. All optical parts have quick fit mounts and are fully pre-aligned. The system aligns itself automatically when the cell type is changed so that no skill is required in operation.

Mastersizer S fully exploits a desk top computer so that measurement control, printing and data storage facilities are state of the art. Software to operate the system is presented under Microsoft® Windows™, the latest graphical user interface standard. Windows™ allows good looking, intuitive and helpful operation which is above all easy to use.

Mastersizer S is easy to use and yet retains powerful flexibility, combining simple push button operation with a full programming language for automation. The EASY mode push buttons can be reconfigured to perform any operation, even down to their screen appearance. A menu system allows fuller control of the instrument whilst retaining a simple interactive and visual approach. The control language is built around a fully featured BASIC and allows users to fully customise their measurement procedures, alter displays and print-out formats for specific applications.

Results and data can be stored and shared with other programmes using standard techniques under the Windows™ system. Clipboard and dynamic data exchange transfers are possible of all data and results, graphs and tables as text, bitmaps or metafiles. This ensures your results are not only recorded and printed but can be directly transferred to your own data management programmes for further manipulation.

By combining the fastest and most flexible measurement method with the best quality optics and the most powerful operating software we arrived at the Mastersizer S series, the most capable particle sizer for modern laboratories.

The Optical Method

The fundamental measurement is achieved using a safe low power visible (helium neon) laser which is expanded until it forms a collimated beam of typically 18mm maximum diameter. This creates the analysing beam through which the particles are passed to scatter the light. The particles must pass through the beam close enough to the receiving lens for their scattered light to be collected, which sets the only limit on measurement position.

The receiving optics comprises a Fourier transform lens with a custom multi element detector at its focus. Unscattered light is focussed by the lens, passes through this detector and is removed and measured. Scattered light is collected by the receiver lens and falls onto the detectors which are organised as a multi-element series of concentric rings and arcs disposed around the focal point. At large angles these detectors are stationed at positions nearer to the scatterer in order to optimise signal detection. Further detectors measure the backscattered light contribution in order to enhance the system sensitivity to sub $0.3\mu\text{m}$ material.

The receiver lens has an important property essential to the correct analysis of the measured data. Light scattered at a particular solid angle from a particle will be transformed so as to strike the detector at a position having the same solid angle when measured from the lens centre, regardless of the particle position. This means that the light from all particles in the beam appears to emanate simultaneously from a single point at the lens centre. This is an optical transformation, virtually instantaneous, and hence works even when the particles are moving. This frees the user to pass the sample through the analyser beam at any speed or orientation allowing sample cells to be simply constructed.

Once the light hits an individual detector ring it creates an electrical signal proportional to the energy received. All the ring data together constitute a data "sweep", which is an instantaneous record

of the scattering pattern rather like a camera snapshot. Sweeps are continuously measured and successively summed during a measurement to create an integral signal for all the particles that pass through the beam. The laser power is also recorded both before and after measurement, which allows the sample concentration to be determined. The final integrated scattering pattern represents the measured data that will ultimately be analysed by the computer to predict the Volume distribution.

Light Scattering from Particles ?

A collection of round single sized particles scatter light into a concentric ring pattern, well known to most school physics classes as Fraunhofer diffraction from a circular aperture. As the particle becomes larger the ring pattern becomes more tightly spaced around the centre, that is the scattering angle of the bright and dark rings reduce. The angular location of these scattering features is what provides the basic size discrimination of the instrument.

However in a normal sample there is a wide range of sizes present simultaneously and so the diffraction becomes the integral sum of the individual responses, each with their dark and light rings mixing. The ring pattern therefore becomes a complex summation requiring separation by computer analysis.

For large particles (4 μm .) the scattering produced is relatively insensitive to any physical properties of the particle other than its projected shape, orientation averaged. Thus a single light scattering theory may be used to predict the detector responses received from any size, regardless of the particle type. Fraunhofer theory has been traditionally used for instruments operating down to 1 μm .

However for smaller particles the scattering begins to be subtly altered by the physical properties of the particulate and dispersant media. The factors that affect the scattering are the particle and medium refractive indices, and the particle absorption. For particles with refractive indices close

to their dispersant, and with low absorption (transparent) the effect is most marked.

Mastersizer S uses Mie theory to formulate its scattering models predicting the detector responses. This is the most advanced theoretical treatment possible for spherical particles, solving as it does the complete Maxwells equations. Mie theory allows the light scattering to be accurately predicted for any size, including the subtle effects caused by the particle properties. A particular combination of these properties is termed a "presentation" in the Mastersizer S. Each requires a complete characterisation of the detector response for each size band of the instrument. Mastersizer S holds a number of prestored presentations for the user to select. In addition a Presentation Generator facility allows the creation of almost any combination, each of which become a permanent extension to the system. Thus where necessary Mastersizer S allows accurate sub micron analysis of almost any material, as the correct presentation can always be created by the user if not pre-installed.

In performing an analysis Mastersizer S utilises this presentation information as it fits the data. It models the exact scattering behaviour of the material when matching the real sample data. This method is greatly superior to many competitive systems which employ a standard analysis and then apply empirical corrections. If you are unable or unwilling to determine basic refractive index information for your sample then Malvern provides a "standard" presentation. If you wish to compare Mastersizer S with other Fraunhofer based systems then a Fraunhofer presentation can be selected. In many competitive systems this is all you will get, in Mastersizer S the latent capability of optical model correction is always available.

The Mastersizer S series offers you a superior choice at no extra cost, accurate presentations for your sensitive particle types, or a simple standard scattering model approach.

Smart Optics Capability

When performing your measurements you want a particle sizer to offer you the ultimate flexibility. The Mastersizer S series is provided with unrivalled capabilities in making the fundamental scattering measurement, delivered by our use of "Smart Optics". Within the Receiver module a complete 16 bit microprocessor system manages the measurement process. Thus your desk top computer is not burdened with the task of measurements and can be reserved for the tasks of data analysis, filing and output. The Smart Optics are more than just a microprocessor, further benefits arise through utilisation of the extra processing power in measurements.

Accurate Measurement

Normal Diffraction based instruments perform a measurement in two stages, a "background" records first the scattering from the system when all the components are present but not the sample itself. A "sample" records the same situation with the sample present and the difference between the two logically extracts the sample scattering contribution for analysis.

The two layer measurement protects the user by making the system tolerant to small amounts of lens or cell window contamination and is utilised by all manufacturers. However it is not perfect in that the background measured is comprised of an electrical component, which is invariant, and an optical component that reduces as the laser beam is obscured by introduction of the sample. Ideally a Sizer should measure both separately and subtract each component accordingly. The Smart Optics performs this process automatically, and without increasing measurement complexity.

When a background measurement is performed the Mastersizer S actually performs two experiments automatically. The first with the laser off measures the electrical component only, and the second records with laser on both electrical and optical effects. In normal measurements the user need not be aware of this process, and operation-

ally views the background as a single measurement.

However, Mastersizer S armed with both background measurements, for every sample taken, is able to more accurately perform background compensation and therefore give more precise results. This is particularly beneficial in sub-micron samples where scattering efficiency is reduced and hence measurement resolution could be compromised.

Accurate Timing

The unit of data capture is a single measurement of every detector value, termed the "sweep". Measurements are normally integrated over time which is achieved by the addition of sweeps taken continually through the experiment. In competitor systems the single sweep is literally obtained by sweeping through each detector point in turn. This method has the disadvantage of smearing the measurement over time, which results in measurement errors if the sample scattering fluctuates at high speed. The Smart Optics however gathers the single sweep simultaneously, using dedicated sample and hold circuits for each point. The complete sweep is sampled within 1 μ S in Mastersizer S and the electronics allows tracking of 8KHz fluctuations. This ensures that data is never distorted by the fastest changing sample conditions.

Once the sweep can be timed to a 1 μ S accuracy it is useful to be able to externally time the start. In rotary engine measurements for example it becomes possible to time the measurement to an exact point in the engine cycle, so that data integration can always be of sweeps from that same point in different revolutions. Such a capability is standard on Mastersizer S with the provision of a "Sweep Trigger" signal to the Smart Optics. Without external triggering sweeps are normally integrated at a 2mS rate by the Smart Optics, ensuring no particles are missed within the beam.

Wide Concentration Range

The electronics of the Smart Optics has very high sensitivity and utilises a 12 bit digital conversion of measured detector signals, to give the widest signal dynamic range possible. The concentration tolerance of diffraction instruments is generally expressed in terms of their obscuration sensitivity. The obscuration describes the fraction of light lost from the main beam to scattering by particles. Thus a 0.05 obscuration means 5% of the laser light is "lost" from the main beam, to scattering and absorption. The actual sample concentration this equates to is a complex function of the particle size and the length of the sample cell. Malvern can provide more details on request.

Measurements on Mastersizer S may be made from laser obscurations from 0.002 up, better than any comparable system. The top limit of concentration is set by the onset of multiple scattering, again sample dependant but typically greater than 0.5 obscuration.

Fastest Measurements

An experiment need not be immediately uploaded for analysis on the PC, it can be stored within the Smart Optics memory. Up to 100 measurements can be held pending analysis, and with battery backed memory this is recalled even after a power down.

Equally impressively the Smart Optics can finish one experiment and start the next within 4ms so that these 100 experiments can follow each other almost immediately. If a single sweep experiment was used, then 100 could be taken within 0.5 seconds using Mastersizer S. This allows explosive, or other single shot spray events to be studied with almost no data loss.

By simple reconfiguration to longer experiments and using timed delays the same Mastersizer S can perform measurements over hours, days or weeks. Thus the Smart Optics give Mastersizer S unparalleled capabilities for the investigation of time varying phenomena, flocculation, aggregation, crystallisation, process exceptions as well as its normal duties. Mastersizer S also has the built in option for external triggering of complete experiments, so that whole measurements can also be timed to coincide with external events.

Once the measurements have been performed the desk top computer can be asked to upload the data,

whereupon it may be analysed, displayed printed and stored as would a "normal" experiment. Thus even for the fastest measurements there is no loss of reporting or analysis quality.

Obscuration Selectivity

In some measurement situations it is very difficult to obtain stable sample conditions due to particle presentation instabilities. A simple example of this would be when measuring material fed under gravity off a process line and through the laser beam. The concentration fluctuates according to the lie of material on the belt, subject to variation outside the operator control. The Smart Optics however has a new feature to help, termed "obscuration selective triggering". The operator can define a valid range of laser obscuration (sample concentration) and during measurement the optics will only then accept a measured sweep for integration should it fall within these valid limits. This allows the Sizer to extract good data only, from an imperfect sample presentation. In the case of the example the benefit is retention of the simplicity of a gravity fed dispersion and avoiding the complexity of a sampler, all through intelligent observation of the received data.

A further benefit in spray measurements, typically of inhalation aerosols, is that the measurement can be triggered to start when spray is detected in the beam and stop when the concentration falls below a minimum. Thus the measurement becomes "self triggered" in that it measures data from the spray whenever the user fires the aerosol, requiring no time synchronisation. This method of operation simplifies measurements of the average behaviour of a spray, it does not substitute for the timed sweep method which allows the user to look into the temporal fluctuation within a single spray pulse. Both capabilities however are unique to Malvern, together they offer the ultimate flexibility in defining measurement conditions.

In built Sampler Interface

To assist in automation of measurement the Smart Optics provides as standard a parallel I/O interface. 12 output lines are available as TTL level signals whose state can be controlled from the desk top PC to allow external hardware samplers to be controlled. In addition 16 TTL input signals are available whose state may be tested by the PC to read back sampler conditions. The Sizer BASIC control language allows the states of these digital lines to be set and read during measurement pro-

cedures. By use of this built in I/O facility most problems of synchronising Mastersizer S to external samplers can be solved.

Flexible Computer Interface

The connection to the computer is via a single standard RS-232C cable ensuring Mastersizer S will operate with almost all desk top PC's capable of running Windows™. The Smart Optics also receives messages for Malvern's smart accessories, and passes them on locally, so that adding an accessory does not require a further computer connection. As a consequence it is easy to site the Malvern computer a long way from the optics, up to 20m as standard. By purchase of an RS 485 interface update this can be extended to 1 kilometre. For process plant applications a fibre optic extension is available that extends this distance up to 3.5 kilometres, providing complete isolation and higher electrical noise immunity.

Further possibilities for extended control systems are possible by the addition to the PC of third party interface cards. The Sizer BASIC language allows general purpose reading and writing of data from cards in the I/O space of the computer. This maximises user freedom to design Sampler control and synchronisation, and avoids any dependence on custom software from Malvern.

Through its Smart Optics the Mastersizer S Series achieves unique measurement capabilities, allowing experiments to be more accurately timed and qualified than any other system on the market. Its capabilities apply to all Mastersizer S Series systems and accessories as standard, they are not expensive options. If you do not require such sophistication today, with Mastersizer S the option is always there, waiting to serve as your needs grow.

Mastersizer S Performance

Mastersizer S can be purchased in two forms, the basic unit comprises a single range optics covering 0.05 - 900 μm . in a compact optical system. An extended version provides a second range which increases the instrument size range to 0.05 - 3500 μm . Any basic unit can be updated if necessary to the extended specification, the addition being modular.

Mastersizer S can provide a measurement repeatability of typically < 0.5%, sample permitting. The reproducibility of results from one Mastersizer S to another is typically < 2%, under identical conditions. Malvern provides an in field verification tool as an optional accessory, it allows users to independently check these claims. Malvern is the only company at present providing such a customer service. Alternatively, Malvern offers a regular service check of the instrument, providing a conformance certificate for quality assurance monitoring.

The resolution available from Mastersizer S is state of the art, but like all instruments in this class is dependant on sample type. Broad distributions will have their peaks less well resolved than narrow ones. Because of this, definitive resolution figures cannot be provided without specific reference to the sample type.

The laser diffraction method can be applied in principle to any one phase of material dispersed in another. The restriction to the user is whether the measurement can be conveniently performed with standard accessories, or via some inaccessible customisation.

The Accessories are described in detail later, here their capability is being viewed in summary. An initial Mastersizer S configuration purchased for one application may always be upgraded by the purchase of other accessories. Here again the Mastersizer S offers security of choice against future changes in your measurement needs.

For powders dispersed in air and liquid, users have an additional choice, of manual or automatic operation. Some Mastersizer S accessories support intelligent operation and can prepare samples and measure them automatically. These accessories are ideal for users contemplating automation, or the use of unskilled operators. Alternatively the manual systems allow a less costly accessory, forgoing the automation.

Automation increases the throughput of sample measurements and will rapidly return its investment where routine size monitoring of a few sample types is performed. Purchasers should think beyond the initial purchase price of the accessory and assess their real sample measurement costs before making a final choice.

It should be clear that standard accessories from Malvern allow almost all useful measurements to be made on Mastersizer S. Accessories also work cooperatively on Mastersizer S so that switching from one type to another is simple and convenient. Therefore as a single instrument serving a laboratory of widely disparate needs Mastersizer S is as ideal as it is for dedicated routine measurements of the same material.

Windows Software

All Mastersizer S series products have an integral desk top PC which performs all the measurement control, configuration and result handling. Software on the PC creates the front panel of the Mastersizer S and the user effects all operations using it. The Sizer software is written using the Microsoft® Windows™ graphical user interface standard. Windows™ represents the most sophisticated operating system available today for PC's.

It provides a standard attractive visual presentation for controls and selections in programmes, this conformity ensures that Sizer is easily learnt and its functions intuitive. It allows the generation of high quality screen and printout formats by supporting artistic representations of data, such as bitmaps and metafiles, as well as text. It has built in support for a wide variety of high resolution colour screens and printers. Through this support the user is able to expand the computer power without needing Malvern to release new software. Windows™ is traditionally associated with a "mouse" which is a special pointing and selection device. A mouse is provided and whilst an undeniably convenient way to operate, the Sizer software can also be fully operated using only the keyboard. Thus in "dirty" measurement conditions an industrial keyboard can provide rugged and complete instrument control.

Windows™ is a multitasking system which means that you can run the Sizer at the same time as you run other applications such as a word processor. Windows™ allows these applications to send data to each other via in built communication features, Sizer data and results can easily be exported into third party software for further treatment. The user is free to enhance the Mastersizer S PC with third party software to augment the Sizer programme.

Attractive Presentation

The most striking feature of Malvern's Sizer software is its visually attractive presentation of the state of the Mastersizer S. The Sizer window is normally presented as a combination view providing a summary of the current activities. There are two main information views, a graph and a table which work together to present a single aspect of the current Sizer information. The table view provides definitive listings of data in an attractive format suitable for direct printing. The graph view usually shows the same type of data presented in a graph form for easier assimilation of trends and overall behaviour.

The information being viewed may be chosen from a wide selection, from different result and data formats to detailed presentation of computer fit errors. The format of the graphs and tables may be completely customised, using different axes types, fonts, colours and so on. This configuration is normally done by a series of pull down menus that lie at the top of the Sizer screen. A menu usually leads to a dialog box where a consistent group of controls is presented. The user makes a new selection and on closing the dialog it takes effect. Menu and dialog selections can be cancelled any time before this point, allowing users to browse the instruments functions without fear of doing something unintended.

Operations such as measurements can also be performed from the menus, allowing full interactive manual control of the Sizer operations and configuration. Special repeat measurement dialogs allow routine repetitive measurements to be carried out using the menu system. These can incorporate the features of Malvern's automatic accessories to allow full control of repetitive new sample dispersion. In addition timed experiments using the Smart Optics storage facilities can be executed with an off-line uploading of the data for analysis. So without any programming quite com-

plex automatic operation is possible using simple menu selections.

EASY to use

Despite the simplicity of menu selection Mastersizer S also supports an easier method of control for unskilled operators, called the EASY buttons. These are a line of special purpose buttons that are displayed below the menu line. Each button has an iconic view intended to depict its function, for example a "Save Result to Disk" button shows an arrow pointing towards a picture of a floppy disk. Using EASY buttons the Mastersizer S can be operated by simply pointing at a picture of what you wish to happen and selecting it. More experienced operators and supervisors will be interested to learn that the number of EASY buttons, their function and even their visual appearance are all customisable. This allows preferred measurement practises to be reduced to a row of sequential operations from the EASY buttons, the ultimate simplification besides a full automation.

Helpful and Friendly

To assist the user still further the Sizer comes with an integral help system which provides a complete manual on the disk. Indeed the help system is better than a manual in many respects as it can be accessed in several context sensitive ways. If you need to make an entry into a dialog and you do not understand it, simply hit the F1 key and you will get help on that dialog. Similarly if there is a menu entry you do not understand then hit Shift-F1 and then select it, help will immediately provide an explanation rather than action the selection.

Help is also organised around a conventional subject index system which can be selected from the help menu item. All help reading is supported by hypertext jumping to related subjects and backtracking, a glossary of terms and a search for subject facility are standard. Sizer help contains a full description of the software operation, but also contains measurement advice and some accessory details. Mastersizer S is the only product sporting such a powerful help system, an investment by Malvern to ensure it remains the easiest instrument to use whilst retaining user flexibility.

Automation and Customisation

The same standard Mastersizer S can also be a fully customised and automatic process monitoring tool with complex result dependant operating procedures and automatic result communication. The Sizer software has at its heart a programming language built around the familiar and ubiquitous BASIC language. In this respect the Sizer programme emulates the best features of the Microsoft® Excel and Word products, the market leading Windows™ software packages. Sizer BASIC is extended with functions that make available to the language the values of instrument data, and commands to action the operations it can perform.

Within Sizer a programme editor allows the user to construct a completely pre-scripted operating procedure as a Sizer BASIC programme. This programme is saved on disk and can then be executed on command. The slickest method to perform this is to paste the programme to a special keyboard key or EASY button. By this means fully programmed operation can be a single keypress away from the normal easy to use menu and button method.

The Sizer BASIC has an impressive range of number and string processing capabilities to allow you to manipulate the basic Mastersizer S result into forms more suited to your final needs. Why transfer Mastersizer S data into another programme for some final consolidated calculation when it could be performed within the Sizer automatically?

Sizer BASIC comes with special commands to allow interaction with operators at run time, they can be prompted for values, which can be error checked prior to use. Interim result data can be flashed to the user through special dialogs that can be created within the language. Status messages may be displayed to indicate the step by step progress of long automation sequences.

Data measured by the Sizer may be tested using the BASIC application. Specific tests to determine fitness for analysis can therefore be developed to prevent an unskilled user from attempting to analyse poor data. Indeed error recovery procedures may be written to coax the operator to redo the procedure, or in the case of full automation to recover a potential shutdown. For product critical

measurements the quality company can create "defensive" measurement programmes capable of virtually eliminating operator misuse.

Sizer BASIC is still more powerful, as it allows the user to design alternative application specific tables and printouts. The standard Malvern versions are all produced using the Sizer BASIC and these programmes are accessible for customisation and adaption. Standard commands and functions of the BASIC allow programme values and text to be placed into tables and printouts, with full colour and font control. In addition lines and boxes allow simple appearance improvement, whilst the ability to incorporate both bitmap and metafile graphics allow extensive embellishment.

Thus through its Sizer BASIC the Mastersizer S Series can safely claim to be the most powerful tool for programmed and automatic measurements available. This facility causes no conflict with the dual claim of ease of use. Button and menu operation co exist with programmed operation within the same software. These capabilities are latent in every Mastersizer S product as standard, providing security of choice should your current needs grow.

Security Protection and Layered Access

With such powerful flexibility Mastersizer S can be readily adapted to users special requirements. However it also brings potential hazards where measurement procedures are subject to stringent control, such as in drug manufacture. In this environment, once a measurement procedure has been designed and the Sizer customised accordingly, the Process manager wishes to "lock down" the system configuration and prevent further change.

The Sizer software allows this by supporting "Layered Access" to the Sizer software in a Security mode. When the optional Security mode is selected a System Controller may take ownership of a particular instrument by setting a password. Once set whenever the Sizer is started the password is requested and access denied for incorrect entry.

The System Controller may then use a special dialog in order to create Users for his system and assign to them individual passwords. Each user may then operate the system by entry of their password. When they do this their user details are automatically entered into result printouts so that the System Controller knows automatically who owns a measurement result.

Each user has his own configuration of the Sizer, each can be a different adaptation of the standard software for particular purposes. More important each user is also granted an Access Level to the Sizer by the System Controller. The Access Level allows the Controller to restrict the ability of the User to alter the Sizer configuration.

Three levels of access are supported from full configurability to none at all. Thus where users are expected to operate tightly defined measurement procedures a Process Manager can preselect the user configuration, deny them the ability to change it and force Mastersizer S to label every result they produce. The password system gives the protection against false data or system misuse needed.

The Mastersizer S is thus able to offer users the flexibility of a programmable instrument, whilst preserving the data integrity needed in tightly monitored applications such as pharmaceuticals. Using Mastersizer S many of the requirements of F&DA validation can be eased by the intrinsic capabilities provided by our Security mode and Layered Access.

What Results are available

The Mastersizer S series provides a wide variety of data and result presentations to help you get the most from your measurements. The fundamental result produced is of the Volume fraction of material in each size class. An auxiliary analysis of the light obscuration allows the volume concentration of a sample to be reported.

The basic volume result can be reported in tabular and graphical form expressed as an oversize, undersize, frequency (continuous curve) or histogram (discrete) form. Any combination of these may be overplotted in a single graph. A group of results may be overplotted on a single graph for fine comparison of trends. Tables are provided at a number of resolutions to suit the users need, from 16 to 100 size band versions. A special page provides the Mastersizer S result plotted on Sieve sizes to ease comparison, the sieve series used may be customised. Special graph formats are provided for Rosin Rammler and Probability forms of result presentation.

Result Modifications

This basic result can be enhanced by a number of user modifications to allow the Mastersizer S to cooperate with other measurement techniques. A basic result may be extended by the manual inclusion of extra Size information from another sizing method looking at the same material. For example in sieve analysis of large size material followed by Mastersizer S analysis of the tails, the retained mass in the sieves can be input as an Extension to the result. For a similar purpose results taken for the same material on different ranges can be Blended to give an overall result consistent across the combined size range of the two measurements.

All particle size techniques vary in their response to non-spherical particles giving rise to shape dependant systematic corrections that should be applied to one technique to compare it with another. Many users of traditional methods attempt to avoid respecifying product criteria by requiring

new size technologies to agree with the older methods. Whilst not recommending the practise Mastersizer S facilitates these comparisons by providing a Shape Correction feature, which allows the standard result to be corrected for comparison. Shape corrections are determined empirically, entered manually and stored on disk for recall when needed. The correction can be turned on and off as a modification of the basic volume result.

Result Transformation

Because the Mastersizer S is sensitive to volume any errors in measurement are uniformly distributed by size when expressed in Volume form. However many users are interested in Surface, Length and Number related behaviour of their samples and would prefer a presentation in this form. Mastersizer S supports a result transform to these distribution forms, based on the assumption that the particles are spherical. The volume distribution is replaced with the new type and can be printed and filed in that new form. All standard Malvern tables and printouts handle transformed results in an identical manner to the Volume, automatic labelling avoids confusion.

Distribution Statistics

To assist further Mastersizer S provides a special table reporting statistical distribution information and percentiles. The Mean, Standard Deviation, Skewness and Kurtosis of the Volume, Surface, Length and Number distributions are all available as standard. In addition the ASTM mean diameters are provided from D[4,3] down to D[1,0]. Other dimensionless width factors are given, the Span and Uniformity, and an estimate of the Specific Surface Area provided. The number and evaluation size of the percentiles are customisable for maximum user convenience.

Data Presentation

Mastersizer S is an open instrument in that the data measured is dynamic and visible throughout the measurement to assist in preparation procedures, and afterwards is viewed and filed with the result. A Data View provides a graph and table of the data including the background measurement.

Data may be re-analysed at any time using different Mastersizer S settings in order to determine the effect of such changes. After analysis a Fit View can be selected to see in detail how closely the computer was able to fit the measured data. Such study can help the experienced user spot good measurement data from bad, and assist optimisation. In many competitive systems the measurement data is never accessible and the user must entrust to a black box approach, reducing confidence. Mastersizer S's open approach to its data and analysis quality gives the user both information and choice in difficult measurements.

Result Statistics

In the case of repetitive measurements of essentially identical material the user becomes interested in the repeatability of results and their trends with time. Mastersizer S is equipped with statistical analysis options that allow results to be collected as groups and their joint statistics determined. Each size class can be analysed over a group of measurements to indicate the group

mean value, one and two standard deviations and the maximum variation. A statistics view allows the mean result to be tabulated and plotted with the fluctuations of the users choice, the graph forming a standard I bar display.

Communicating Results

Mastersizer S offers other features to cooperate with the user over data and result sharing. Both data and results may be "cut and pasted" to allow the information to be shared with other applications. Thus any further and more complex statistical manipulation of results for example can be supported by pasting the results to a spreadsheet and using the in built functions of that to gain the extra analysis. Mastersizer S allows "hot linking" of its data and results to applications supporting the Dynamic Data Exchange format of Windows™. This feature is like a continuously updated paste operation, which can make such extensions operate automatically.

It should be clear that the Mastersizer S Series recognises the users legitimate interest in the measured data and the widest possible assistance in result interpretation. Through its range of built in Views, Modifications and Transformations, its ability to statistically analyse groups of results and its unparalleled data access to Third Party software, it gives the user the security of choice.

Mastersizer S Accessories

For Aerosol Measurements

To perform measurements on aerosols the Mastersizer S adopts its simplest form, requiring no sample accessories at all. An aerosol needs to be directed through the laser beam from its generating source, and the particles collected safely after passing through the beam. The user simply brings the spray to the Mastersizer S optics, or for a more complex rig installs the MasterSizer around the nozzle. MasterSizer is flexible in that it may be dismantled to a modular Transmitter and Receiver unit, which can be fixed to a custom rig mount.

The MasterSizer measurement is usually performed using continuous integration of sweeps, where the aerosol generation is stable and continuous. However every Mastersizer S has the option to perform measurements from accurately timed sweeps, where aerosols are time variable. Aerosols can be pulsatile as in the case of diesel injector fuel sprays, or single events such as chemical rocket exhausts.

To assist in the placement of the aerosol the Mastersizer S allows the "working range" of the optical unit to be altered. Essentially the user is free to exchange some low end size range capability for an increase in the working length of the laser beam. This allows larger sprays to be accommodated whilst ensuring that data is collected over their full extent.

Aerosol Mounting Unit

For the measurement of aerosols one useful accessory is a means of fixing the generating nozzle at a defined and repeatable point in relation to the laser beam. The Aerosol Mounting Unit is a mechanical mount that fits rigidly to the Mastersizer S and provides control of a mounting head position in X,Y and Z axes. The head is designed for the convenient fitting of Aerosol cans with a wide range of diameters and heights. It also allows the

fitting of many types of inhalers, and nebulisers. The Aerosol Mounting Unit is also useful for non standard situations, where the user may be able to supply a custom adaption to replace the standard stage.

Malvern's Infra Red Trigger Sensor may be fitted to the mount so that it is possible to conveniently obtain a "Spray Trigger" signal for timed measurements. It may be positioned so that the spray passes through the sensing zone on its way to the Mastersizer S, thereby generating a trigger signal for measurement.

Pulsed Spray Capability

The Mastersizer S has the ability to time its measurements as an intrinsic capability of the Smart optics. The user can provide electronic synchronisation for the experiments themselves, via an "Experiment Trigger", and for the individual data sweeps that comprise an experiment, via a "Sweep Trigger". Within the software the user merely selects whether to use internal (free running) or external (timed) triggering for each of the experiments and/or the sweeps.

To obtain a trigger signal from an experimental rig requires the user to identify how to obtain a signal that occurs at the same frequency as the aerosol generation. For most applications the requirements for trigger generation may be met using optical sensors provided by Malvern. In some cases a trigger signal will be already available without further work.

Infra Red Trigger Sensor

The Infra Red Trigger Sensor is a sensor designed to observe the sudden passage of a cloud of particles passing through an inbuilt optical transmitter and receiver pair. When particles are detected in the gap between a signal is generated, which is passed to the Mastersizer S as an appropriate trigger. The sensor is normally placed just in front of the Aerosol Generator so that it obtains an accurately timed pulse indicating the time of origina-

tion of the pulse. The accessory has a range of configurations selected via DIP switches, these allow optimum signal filtering for different spray types.

Rotational Trigger Sensor

The Rotational Trigger Sensor is a reflective optical sensor that is normally used to gain accurate timing of rotating machinery such as an engine camshaft. It is useful where the aerosol is generated by a machine having moving parts operating at the spray frequency. A reflective strip is applied to the shaft and the sensor provides a trigger whenever this comes into view. The sensitivity of detection is user controlled to allow optimum timing accuracy to be achieved.

For each accessory the user may set a delay time before the trigger operates within the Sizer software. This allows compensation for any time of flight between the sensing point and the laser beam. Therefore the trigger does not need to be synchronous to the time at which measurement is desired. All further delay timing and experiment control is performed by the Sizer software. The user may write programmes within the Sizer BASIC to perform multiple experiments at predetermined time delays, to ease the labour involved in characterising time variant processes.

For Wet Powder Dispersion

The dispersion of particles into a liquid remains the most popular method of sample preparation for laser diffraction systems. Essentially the candidate sample material must be dispersed into an inert carrier liquid, its concentration adjusted into a broad acceptable band, and the sample pumped through a cell to expose the particles to the laser beam.

Problems can arise when the particles either react with most acceptable liquids available for dispersion, or they agglomerate without dispersion. Here the sample may require positive action to promote dispersion, the most common mechanical method being by use of ultrasonic agitation of the sample. Additives in the form of surfactants or admixtures can alter the lyophobic tendencies of some particles to promote dispersion.

In order to have the most flexible liquid dispersion system the user requires an Accessory that tolerates a very wide range of dispersants, from water through to aggressive organics. This maximises the user choice regarding dispersant type and gives therefore the greatest prospect of identifying liquids that promote dispersion. The user desires a large sample volume to ensure as many particles are measured as possible, but may have a disposal hazard if the dispersant is toxic. In such cases the ideal solution is to support a range of dispersant volumes that can be selected according to best need. Malvern offers the liquid sampling systems detailed below as part of an ever growing list of accessories.

In some cases a suitable liquid carrier may not be conveniently available, in which case airborne dispersion may be considered. Malvern also offers a full range of Dry Powder Feeder accessories.

Magnetically Stirred Cell

When handling toxic or highly valuable sample or dispersant materials it is desirable to work with the smallest practical volumes available. At 15ml volume the Magnetically Stirred Cell system is the smallest on the market. Constructed in 316 stainless steel it has Viton seals (Kalrez optional) and a PTFE bead stirrer ensuring very high chemical integrity. The sample is stirred by a magnetic stirrer system outside the cell so that the bead is the only component in contact with the sample other than the cell body. The cell system mounts as a quick fit module into the Mastersizer S optics, and the cell is simply snap-located into this for measurement. The cell is removed for cleaning and sample recovery. A top is included on the cell to ensure there is no spillage during handling. The sample is typically predispersed to a slurry form prior to measurement, so that sonification and any additions are rarely done within the cell itself.

Small Volume Sample Dispersion Unit

Again for toxic or valuable materials the Small Volume Sample Dispersion Unit offers a measurement volume of typically 50-80ml. In this accessory the sample is held in a separate small preparation unit, and is pumped to the standard flow cell of the other, larger Malvern accessories. Chemical integrity is identical to the Magnetically Stirred Cell with the exception of the tubing that connects the cell to the Small Volume Sample

Dispersion Unit. As supplied this is Tygon, although being a standard size it may be replaced with any more compatible tubing by the user. Full sample recovery is achieved by a drain mechanism that will restore the full mixture to a beaker.

The main additional benefit of the unit is that by use of a flow through cell design, higher stirring and pumping energies can be applied to the sample without losing the small dispersant volume benefit. This is helpful for dense particulates where sedimentation may occur unless vigorous stirring and sample flow is maintained.

Sample Dispersion Unit

The Sample Dispersion Unit is a large volume dispersion unit having a capacity of up to a litre of dispersant. This restricts its suitability to liquids that can be handled and disposed of safely in those quantities. Consisting of a tank system which pumps the mixture to the standard Flow Cell the unit can be filled either manually, or by plumbing in to laboratory supplies. Waste mixture is ejected via a drain tube for disposal according to needs. Despite its size, the chemical compatibility of the system is identical to that of the Small Volume Sample Dispersion Unit.

The tank incorporates an inbuilt 50W ultrasonic dispersion unit whose intensity and duration may be manually controlled. This allows mechanical dispersion to be tuned to achieve the maximum breakup of agglomerates whilst not destroying any delicate primitive particles. The mixture is stirred to maintain the dispersion without sedimentation. The stirrer rate may be manually controlled, to ensure maximum stirring whilst avoiding aeration of the dispersant. The dispersed mixture is flowed around to the cell via a pump whose flow rate may also be fully controlled.

Sample concentration may be adjusted into the measurement range either by addition of more sample, or dilution through the addition of more dispersant, the excess being floated off to waste through an inbuilt overflow.

The Sample Dispersion Unit is controlled manually from a front panel, measurements are performed by a series of steps performed on this front panel and the Sizer computer. This represents the main difference between this unit and the Automated Sample Dispersion Unit, which (as the

name suggests) includes automation. The user should view the two systems as identical as regards application suitability, the decision between them being the cost and worth of the automation.

Automated Sample Dispersion Unit

The Automated Sample Dispersion Unit has the same basic capabilities as the Sample Dispersion Unit with regard to sample volumes, controls and chemical compatibility. However it has full automation, in that from the Sizer computer it is possible to preprogramme all aspects of the dispersion, to create automatic dispersion procedures. The user may control dispersant addition and cleaning, stirring, pumping and ultrasound power and duration via programme control, as well as conventional manual use. The Automated Sample Dispersion Unit is intelligent and performs its own sample disposal procedures, allowing overlap of sample handling with data analysis and printout, for maximum measurement throughput.

A significant feature of the unit is the provision of a "slurry injection port" which consists of a feed and return line from an on line process. The user organises the process material to be pumped through this feed and return line thereby sampling the manufacture of the slurry material. The unit is then able to inject sample from this slurry line into the tank, allowing fully automatic sample addition. Coupling this with the full control of dispersion criteria by programme and the user is able to fully automate the routine sampling of the slurry. The injection port has a zero dead volume and is able to inject very small doses of concentrated slurries directly. Slurries of up to 30% volume concentration may be sampled directly without pre-dilution. As a custom adaption Malvern can offer system prices for Automated Sample Dispersion Units fitted with multiple slurry injection ports, which allow the routine multiplexing of the measurement capability around different parts of a process.

To capitalise on these automation features the Sizer software implements an "automatic concentration" feature which allows the user to set an ideal concentration range for the measurement. The Sizer then injects sample and dispersant automatically as needed to ensure that each measurement meets the desired condition eliminating any error.

Other features within the Sizer software ensure that the automation of measurement is a practical rather than theoretical proposition, from inbuilt process control interfaces, the ability to qualify its own measured data, through to auto programme start after power up Mastersizer S is the only system offering full automation.

X-Y Autosampler

The X-Y AutoSampler is an accessory that operates with the Automated Sample Dispersion Unit to further exploit its automation features. It comprises a 40 sample capacity tray into which the user may place sample for measurement either dry powders or concentrated, predispersed slurries. When a sample is due for measurement an XY head will locate it and perform a dispersion operation within the sample pot. This predispersion can include optionally wetting down or dilution of the sample, adding of up to three separate additives and stirring. Finally a defined volume of the sample is taken and injected to the tank of the Automated Sample Dispersion Unit for final sonification, dilution and measurement.

The X-Y Autosampler is controlled by a separate Scheduler programme that multitasks with the Sizer automatically. At any time, including during measurement, the user may add a new sample to the rack and identify it to the Scheduler. Sample position may be random and a priority may be established for the sample on entry of other data such as result labelling. The preparation procedure to be employed may be selected for all, a group or even individual samples from prepared lists. The preparation programmes may be customised by the experienced user.

The Scheduler dynamically introduces the new sample and reprioritises its work accordingly, all without stopping the measurement in progress. The state of operation of the AutoSampler is indicated by a visual mimic of the sample tray with colour coding indicating samples done, in progress and waiting. Schedules may be paused or abandoned and can be left unfinished on power down, they will optionally continue from where they left off when next used. Whilst operating the user may switch from the Scheduler view to the Sizer view at will, without interfering with operations in order to assess progress.

For Dry Powder Dispersion

The dispersion of materials into air or other inert gas so that they may be blown through the laser beam is an increasingly popular method of dispersion. However the need to provide compressed air for dispersion and vacuum recovery to collect the sample afterwards means that it is a more complex installation for the user. For this reason it is normal to explore a liquid dispersion first, moving to dry when this proves particularly difficult to achieve.

An ideal dry dispersion system would provide sufficiently aggressive mechanical action to ensure total breakup of agglomerates. In practice the energies required to break up tightly bound sub micron agglomerates are so high that in the same feeder large particles would suffer attrition. For this reason, as with liquid systems, the solution is to provide a range of accessories tailored to individual measurement situations.

Free Fall Dry Powder Feeder

This accessory provides the gentlest handling of a powdered material and is suitable for free flowing materials. It comprises a magnetic vibratory feeder which meters the sample down a chute which forms the material into a thin curtain which falls under gravity through the laser beam. The sample chute and associated Air Cell are a quick fit to the Mastersizer S for speedy integration with other accessories. The Air Cell is equipped with Windows to ensure that the dry powder is isolated from the Mastersizer S optics, protecting the system from contamination.

The feed rate is controlled by variation of the vibrator intensity and a series of baffles spreads the material into a suitable curtain of individual particles. As there is very little mechanical action this feeder is suitable for free flowing or fragile materials. Tightly bound agglomerated materials are better handled by other Malvern accessories.

Sample may either be recovered into a catching tray, or totally exhausted to a vacuum collector for convenience. Vacuum collection is compatible with use of a small industrial vacuum cleaner and Malvern provides a suitably controlled power outlet for this purpose. A hybrid mode of operation can be employed where the sample is recovered but a small vacuum extraction is applied to avoid fine dust backing through the Air Cell. This is

suitable for some materials where fine material can be liberated from larger particles on coming to rest.

The ability to fully recover the sample after dry measurement, coupled with Malvern's unique "obscuration selective measurement" feature allows the Feeder to be used for small quantities of valuable or toxic materials. Sample volumes of 1cc can be measured of materials such as diamond powders, a routine capability unique to Malvern.

Dry Powder Feeder

The Dry Powder Feeder provides a more aggressive dispersion action and is suitable for finer and more agglomerated materials. The sample is placed onto a vibratory feeder which meters material into a matrix of fine metal balls. The material flow is smoothed out and large agglomerates broken down at this stage with the outflow falling into a compressed air injector. The remaining fine agglomerates pass through the high air shear of the injector and are separated into constituent particles carried in a fast moving air stream. This powder aerosol is directed across the laser beam through an Air Cell and passes on to a Vacuum extraction system. The Air Cell has a quick fit mount for convenience, and isolates the Mastersizer S from the sample material to avoid contamination.

The material is collected using a small industrial vacuum cleaner typically and Malvern provides a suitably controlled outlet for this purpose. The measurement is a total loss process and reasonable quantities of material are required for each measurement, typically 25 ml. Control of the Feeder is manual via an integral front panel with the feed rate being the only necessary control in the dispersion process.

Automatic Dry Powder Feeder

The Automatic Dry Powder Feeder provides full automation capabilities for Dry Powder measurement with sample capabilities broadly similar to those of the standard Dry Powder Feeder. The sample is loaded into a cassette, the bottom half of which forms a vibratory feed of the material. The cassette is removable for cleaning and to allow the

possibility of one sample being prepared for measurement whilst another is being measured. Two cassettes are provided one being optimised for larger free flowing materials, the other for finer and more agglomerated types.

Material is fed into a rotary brush disperser which breaks up agglomerates and meters the outflow uniformly into a compressed air injector stage. This disperses the finer agglomerates in the high air shear and creates a fast moving powder aerosol which is directed to the Air Cell for measurement. The Air Cell is identical to that of the standard Dry Powder Feeder unit and serves an identical purpose. The material is collected in a vacuum extraction system after measurement and is totally lost.

Material that is loaded into the cassette but is not required to complete the measurement could simply be blown through the system to clear it. However to conserve wear on the system and to retain the efficiency of the vacuum collector it is also possible to go into a "waste mode" which allows material to be fed to a collection tube. This tube may be connected to a separate vacuum collector, or simply to a bag so the material is recovered under gravity.

The Automatic Dry Powder Feeder accessory is intelligent and capable of full control from the Sizer software. The system can be put into any one of its operating modes and the material feed rate adjusted by the Sizer software as well as via manual controls. This allows the user to construct dry powder feed measurements entirely under preprogrammed control allowing use of unskilled operators and enabling measurement automation.

To maximise the attractiveness of this the Sizer software includes an auto metering facility which allows the Sizer software to control the material feed rate automatically. Thus complex interactive control of the accessory by the user is avoided and measurement simplicity achieved. The decision to employ the Automatic Dry Powder Feeder must be taken based on the cost and worth of its additional automation features over that of the standard Dry Powder Feeder unit.

Extending your Mastersizer S

The Mastersizer S series of products is subject to a continuous development by Malvern. We are committed to maintaining a modular design for the Mastersizer S meaning that new developments will generally be capable of retrofit to existing systems. You should contact Malvern when you have new measurement needs and we can advise of our latest additions to the range. The list following represents the main extensions you may consider to your Mastersizer S purchase, either at time of purchase or later.

Range Extension Kit for Mastersizer S

The standard Mastersizer S optical system allows measurements over the range 0.05 - 900µm, utilising a single measurement range. This may be extended to 0.05 - 3500µm, by purchase of the Range Extension Kit. This comprises a new optical bed, lens support and safety covers together with the range lens itself. The old system is transferred to the new optical bed and the new covers added, after which all previous ranges remain as before, but a new 1000mm lens range has been added. All Malvern accessories will work with the new lens and thus no investment in existing equipment purchases are jeopardised.

Fibre Optic Computer Line Extension

The Mastersizer S computer connects to the optical system and the associated accessories via a single RS-232C cable. This simple and low cost interface may be extended up to 100 metres to allow the computer to be sited away from the sample area where high degrees of automation are being considered. To go beyond this Malvern offers a Fibre Optic based interface kit which allows the direct wire link to be replaced with low cost fibre optic cable. Once installed the computer is fully electrically isolated from the optical unit and will exhibit interference free communication up to 2 kilometres apart.

Alternative Computers

As Mastersizer S Series products contain a desk top computer as a discrete component the user may have an interest in using the computer for other activities when not performing measurements. To this end we offer prices to upgrade the computer to meet any user requirements. Our basic offering can be enhanced at time of purchase by upgrading the CPU, clock speed, memory, disk capacity and screen type. The specification sheet provides more details. Malvern provides an internationally recognised computer so that the user may also choose to upgrade the initial purchase, using local suppliers.

Alternative Printers

The Sizer software provides very high resolution colour printout capabilities which are managed by the Windows™ operating system and directed to the installed printers. In principle therefore Mastersizer S can print to any printer for which a Windows™ driver is available. This ideal situation would allow users to purchase almost any printer and expect it to provide excellent results. In practise many problems exist with third party printer drivers and the user is strongly advised to run any potential printer with the Malvern software and their own applications prior to purchase. Malvern offers a range of printers for which compatibility is guaranteed for the Sizer software, and offers no warranty or support on others.

Third Party Interface Cards

The Sizer BASIC language has built in functions that allow numbers to be read in from, or written out to, the computer input/output address space. This allows the user to purchase a third party interface card and fit it into the Sizer computer. The programming requirements to operate this card may then be created using a Sizer BASIC programme, allowing it to be integrated into particle sizer operations. Examples of cards that may interest users are multiple 0-20V analogue outputs and inputs, multiple 4-20ma current loop outputs

and inputs, and so on. Remember that Mastersizer S already has a built in digital input and output capability as part of its Smart Optics, this may satisfy all your requirements without further purchase.

Malvern offers this facility without detailed technical support as a service to customers interested in integration of the Mastersizer S with other process or automation hardware. Any choice of third party board should therefore be verified for suitability by demonstration prior to purchase.

Specialist Cells

Whilst Malvern offers a wide range of accessories it is impossible to anticipate all possible sizing requirements. To assist users in specialist measurements we offer a custom cell design service where we will assess customer requirements and offer one off development contracts where appropriate. Malvern has already experience of providing temperature control, high pressure cells, thin section cells, optical adaptations and so on. Please contact us with your requirements if not met by items in our current Specification list.

TEST METHOD
FOR
MALVERN MASTERSIZER S LASER DIFFRACTOR

Company: BLASLAND BOUCK & LEE, INC.

A. Instrument/Software Set-up

- A.1. Turn laser and instrument ON. Allow laser to warm up for 30 minutes.
- A.2. Initiate computer interface and data reduction software.
- A.3. Set up hardware.
 - A.3.1. Range: 0.05 to 900 microns
 - A.3.2. Active Beam Length: 2.4 mm
 - A.3.3. Lens: 300mm (300RF)
- A.4. Set up analysis.
 - A.4.1. Analysis Model: Polydisperse
- A.5. Set up presentation.
 - A.5.1. Wet: 3OHD
- A.6. Align laser
- A.7. Measure background.
- A.8. Enter sample ID information.

B. Sample Preparation and Dispersion

- B.1. Select one filter at random and wet with Triton X-100 and sodium pyrophosphate. The particulate was collected in a large beaker. <
- B.2. Ultrasonicate the sample for two minutes in a Bransonic 3 ultrasonic bath.
- B.3. Examine prepared sample suspension on the microscope to verify the quality of each dispersion.

82697094

Particle Technology Labs

Page 2 of 2

C. Sample Analysis

- C.1. Fill the Malvern recirculating bath with water (approximately 125mL).
- C.2. Using a transfer pipette, add enough sample suspension into the carrier fluid bath to obtain an obscuration level in the range of 20 to 30 percent; the ideal range of obscuration set by the instrument manufacturer's parameters.
- C.3. Once the proper obscuration range is achieved, initiate the software to measure four analyses, at one-minute intervals. The client, Blasland Bouck & Lee, is typically given the one-minute reading analysis.

D. Instrument Parameters

Software:	2.18
Suspension Obscuration:	20 - 30% optimal
Suspension Flow:	Malvern bullet recirculator
Table/Result Display:	Under percent/Under percent
Data Presentation:	Volume
Beam Length:	2.4 mm
Optical Focus:	300mm lens
Optical Theory:	3OHD
Analysis Model:	Polydisperse

This Test Method has been written under the assumption that the reader has a full understanding of the methods of operation on a Malvern MasterSizer S LASER diffractor. A step-by-step method of operation can be referenced in the *Malvern Mastersizer S Laser Diffractor: Malvern Basic* manual.

Introduction

Malvern's Quality Audit Standards have been produced to provide users of Malvern particle size analysers with a reliable one-shot polydisperse transfer standard to enable them to check the performance of their sample dispersion units.

One shot packaging eliminates sampling error

The usual problem associated with the use of polydisperse glass bead standards is that they are prone to segregation in transit so that sampling errors can occur.

Malvern's Quality Audit Standards have been produced by one of Europe's leading suppliers of glass bead standards, Whitehouse Scientific, who have used an extremely efficient and accurate riffle splitting process to ensure that each one-shot pot of the material is a representative sample of the whole bulk of sample material.

Comprehensive sampling of pots taken from the whole production run of the reference material has allowed us to establish and document confidence limits on the sample material of not less than 95%.

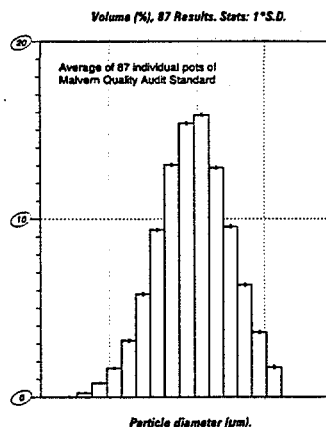


Figure 1. Statistics plot of 87 separate samples extracted from all parts of the fitting process - see Certificate of Analysis. The error bars illustrate the consistency of the particle size distributions yielded by these samples.

An extensive programme of testing of Malvern's sample dispersion units has been carried out and is continuing to characterise the results which may be expected from them in order to establish pass/fail criteria for the purposes of OQ testing of these units.

To ensure that the full benefit is obtained from the single shot concept, it is essential that the entire contents of the bottle is consumed in a single measurement.

Three separate pack sizes of the standard material have been produced in order that users can obtain the correct level of obscuration with most Malvern sample dispersion units. These are:

QAS2001 (0.25g), QAS2002 (2.5g) and QAS2003 (5g)

Protocols for the use of each of these standards with their associated sample dispersion units are given overleaf.

MALVERN VALIDATION INITIATIVE 2000

Measurement protocols for Malvern Quality Audit Standards
QAS2001, QAS2002 and QAS2003

M R K 3 4 5 - 0 2



These samples are traceable back to NIST by a transfer method since they have been characterised on a reference Mastersizer S which in turn has been verified using NIST-traceable polystyrene latices as well as a Reference Reticle which is also NIST traceable.

A fully documented programme of testing has been carried out to establish that the bottles of sample material are identical to each other to an uncertainty of 0.36 microns on the d50 of 49.26 microns as recorded on the facsimile Certificate on the right of the page

Expected Results

Category One Sample Dispersion Units

These are sample handling units which will give results most similar to the results obtained in the consistency testing of the Quality Audit Standards by virtue of the similarity of their configuration to the test unit used and their larger sample capacity.

Category 1 is subdivided into category 1a and category 1b units. Category 1a units are Malvern's QSpec Sample Dispersion Units and Mastersizer 2000 Sample Dispersion Units. Category 1b units are Dry Powder Feeders and units produced before Malvern's introduction of QSpec and their ISO 9001 and Tickit procedures in August 1996. These units may exhibit a slightly wider variation as indicated below.

Category 1a Large Volume Dispersion Units	Hydro 2000 G
Category 1b Large Volume Dispersion Units	MS15, MS17 (DIF 2002)
Category 1b Dry Powder Feeders	MAM 2461, Scirocco 2000
	MS64, MAM2460, MS65

The expected limits for Category 1a units are 2% on the Dv50, 3% on the Dv10 and Dv90. Category 1b units are 3% on the Dv50 and 6% on the Dv10 and Dv90.

	Dv10	Dv50	Dv90
Cat 1b Lower Limit	26.79	46.07	73.32
Cat 1a Lower Limit	27.64	46.55	75.66
Median Values	28.5	47.5	76
Cat 1a Upper Limit	29.35	48.45	80.34
Cat 1b Upper Limit	30.21	49.92	82.68

Category Two Sample Dispersion Units

These are small volume sample dispersion units and dip-in pump units (which use a beaker as the sample tank) and which do not have the same dispersion configuration as the category one units.

Owing to their different configurations, they will deliver a slightly different median value.

Category 2 is subdivided into category 2a and category 2b. Category 2a units have feedback to the pump and stirrer control so that they are able to deliver a higher level of precision than Category 2b units which do not have feedback and may therefore exhibit a slightly wider variation as indicated below.

Category 2a Small volume Sample Dispersion Units and Dip-in pump units	DIF2021.
	Hydro 2000 SM.
	Hydro 2000 S.
	Mastersizer Micro and Micro Plus with 1000ml beaker.
	Hydro 2000 M and Hydro 2000 MU with 1000ml beaker.
Category 2b Small Volume Sample Dispersion Units	MSX1, MS1

The expected limits for Category 2a units are 2% on the Dv50 and 3% on the Dv10 and Dv90. Category 2b units are 3% on the Dv50 and 6% on the Dv10 and Dv90.

	Dv10	Dv50	Dv90
Cat 2b Lower Limit	26.72	45.39	72.38
Cat 2a Lower Limit	27.57	45.86	74.69
Median Values	28.43	46.8	77
Cat 2a Upper Limit	29.28	47.73	79.31
Cat 2b Upper Limit	30.13	48.20	81.62

Ongoing results from the same sample dispersion unit

The quality of the Quality Audit Standards is such that, provided the material is used as a single shot, the ongoing repeatability for any single sample dispersion unit is likely to be better than 1% on the d50 and 2% on the outlying percentiles for that unit.

Even if your unit is not listed under expected results, the Quality Audit Standards will provide an invaluable means of bench-marking the performance of your sample handling unit on a regular basis.

Certificate of Analysis

Sampling Strategy and Particle Size of
Quality Audit (Transfer) Standards

Master-batch reference MAL010/9801
Package references QAS2001, QAS2002, and QAS2003

1. Preparation

Soda-lime glass beads were graded into fractions from 15 to 150 microns using a Gison Production Sonic Sifter and recombined to produce a near Gaussian distribution about a mean size of approximately 50 microns. The 250 Kg master-batch was then thoroughly mixed prior to the sub-division.

2. Subdivision

Proprietary 100 stage spinning riffles were used to minimise the handling to 3 generations (4 for the 0.25g samples). The repeatability was based on randomly selected 2.5g samples produced at the third generation and summarised opposite.

3. Analysis

The 81 samples extracted were analysed using a reference Mastersizer S - serial number 33285-11. From the sizes at fixed percentiles, the mean (S) and the standard deviation (SD = $3\sigma_{(S)}$) were calculated. The data was used to determine the uncertainty of each point to a confidence level of not less than 95%. Measurement uncertainty defined herein = $2 \times (R\sigma_{(S)})$ and means that there is better than a 95% chance of the size falling in a range \pm twice the sample standard deviation.

4. Results

Percentile	1	5	10	25	50	75	90	95	99
Mean (S) - μ m	18.47	24.84	29.12	37.21	48.28	62.44	79.06	90.00	108.04
SD = $3\sigma_{(S)}$ - μ m	0.10	0.13	0.13	0.15	0.18	0.27	0.35	0.40	0.28
Uncertainty - μ m	0.20	0.26	0.26	0.30	0.36	0.54	0.70	0.80	0.48

Thus the median size = 48.28 \pm 0.36 microns

Sampling strategy for repeatability analysis

Master-batch
250 Kg

10 stage spinning riffle

100 stage spinning riffle

3 random 250g samples taken from each stream - 9 x 3 = 27 in total

27 samples - 100 stage spinning riffle

3 random 2.5g samples taken from each stream - 27 x 3 = 81 in total

Notes:

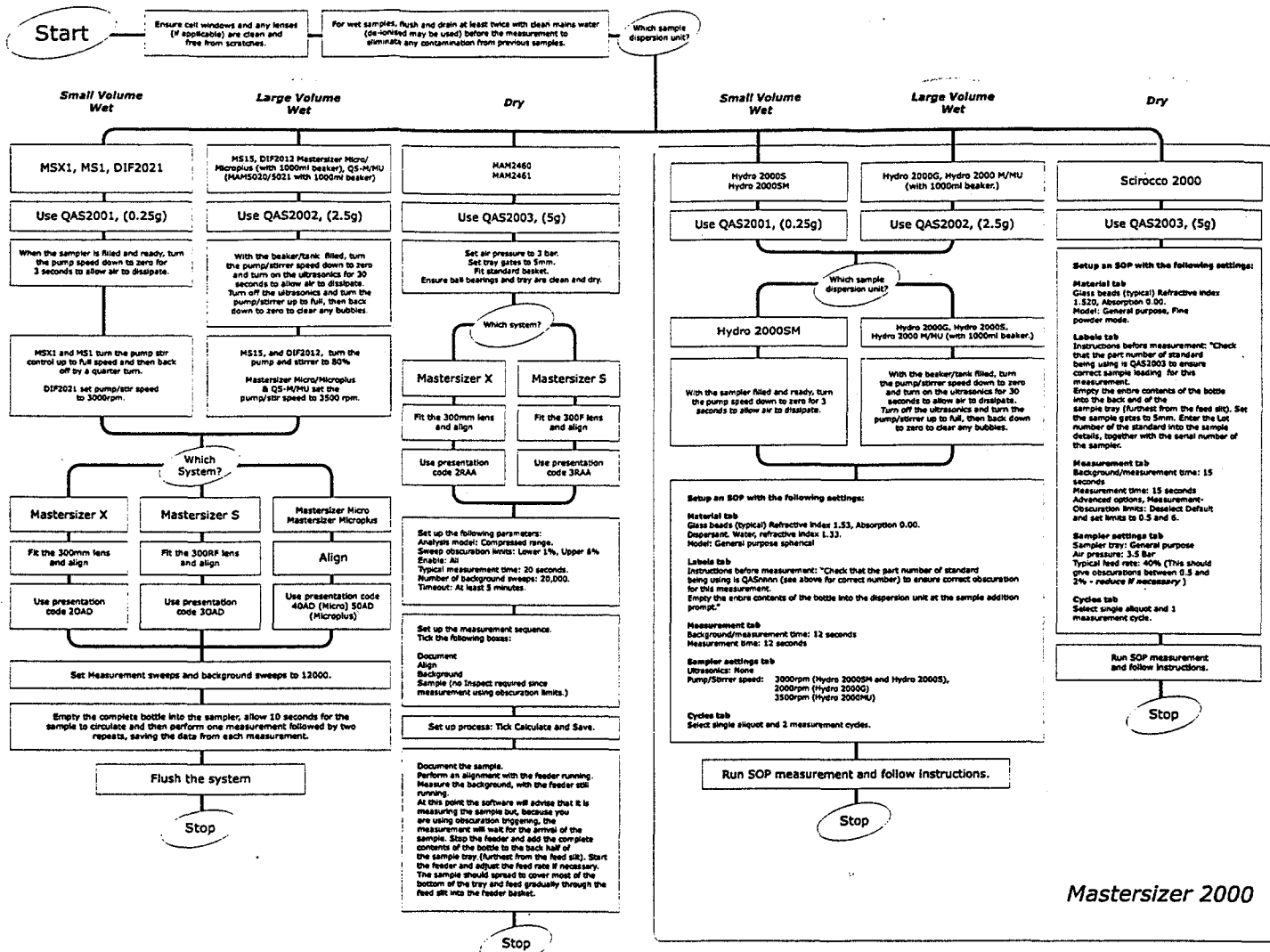
(1) Preparation details on anc analysis performed by: *[Signature]* Dr G R Roper, Chief Scientist
Wttrahouse Scientific, Chester, England

(2) The Quality Audit Standards described above are made in the UK exclusively for Malvern Instruments Ltd.

Wttrahouse Scientific
15.2.99
STANDARDS

The certificate relates to the **uniformity** of the Quality Audit Standard.
See "Expected Results" for information about the values which can be expected from your sample dispersion unit.

Measurement procedures



Health and Safety Data

Product Name: Malvern Quality Audit Standard Material QAS 2001, QAS 2002 and QAS 2003.
Manufacturer: Whitehouse Scientific Ltd. The White House, Whitchurch Road, Waverton, Chester, CH3 7PB
In case of Emergency call: +44 (0) 1244 335063

Composition Information on Ingredients:
Chemical Composition %
SiO₂ 72.5%
NaO 13.7%
CaO 9.8%
MgO 3.3%
Al₂O₃ 0.4%
FeO/Fe₂O₃ 0.2%
K₂O 0.1%
Cas Number: 65997-17-3
Index Number: 000-000-00-0
EINECS Number: 266-046-0

Potential Health Hazards:
Eyes and throat can become irritated when exposed to too high concentrations. There are no significant immediate health, physical or environmental hazards.

First aid measures:
Inhalation: Remove to fresh air.
Skin: Wash with water and soap.
Eyes: Wash with plenty of water. If irritation persists, consult a physician.
Ingestion: No danger known.
Advice to physician: No specific advice. Treat according to symptoms present.

Fire-fighting measures:
Not applicable

Accidental release measures:
Personal protection: Wear recommended personal protection equipment.
Procedure for cleaning and recuperation of spilled material: Sweep up gently to minimise creation of dust. Collect in a suitable container e.g. fibreboard drum or carton.

Handling and storage:
Handling: Avoid breathing dust. Avoid spillage which can cause slippery floors. Use good personal hygiene and house keeping.

Storage recommendation: Keep bags and containers well close. Store cool.
Storage class: 10-13

Exposure controls/personal protection:
Engineering controls: Use adequate ventilation if dusty conditions prevail when handling the product. For storage and ordinary handling, general ventilation is adequate.
Dust: 5mg/m³ max. (no free SiO₂, all components are amorphous/non-crystalline).

Exposure guidelines:
Respiratory Protection: Use a NIOSH-approved dust respirator with powdered grades if dusty conditions prevail.
Skin protection: Protective garments.
Eye protection: Goggles.

Physical and chemical properties:

Appearance:
Physical state: Solid
Colour: White
Odour: None

Safety relevant data:
Melting point: ca. 730°C
Lower explosion limit: Not applicable
Upper explosion limit: Not applicable
Specific gravity: ca. 2.6g/cm³ (20°C)
Solubility in water: Not applicable

Stability and reactivity:
Not applicable

Toxicological information:
Immediate (acute) effects: Not applicable

Disposal considerations:
Discard as non-hazardous inorganic solid waste.

Transport information:

Land transport:
ADR Not regulated
GGVS Not regulated
RID Not regulated
GGVE Not regulated

River/canal transport:
ADNR Not regulated

Sea Transport:
IMDG/IGV Sea-code Not regulated
EmS MFAG Not regulated

Air Transport:
ICAO/IATA-DGR Not regulated

Identification of the product:
Danger number: UN nr

Other information:
May be sent by mail

Regulatory information:
Danger symbols Not regulated
National Regulations Not regulated

Other health, safety and regulatory information:
The information contained herein is to the best of our knowledge accurate but, since the circumstances and conditions in which the material may be used are beyond our control, we do not accept liability for any loss or damage which may result directly or indirectly from the use of such information.

82697099

Attachment 2

82697100

Table 4-2. Sample Bottle, Weight and Preservative Specifications for Chemical Analysis of Sediment Samples¹

Parameters Analyzed	Absolute Minimum Sample Weight ² (dry weight)	Desired Minimum Sample Weight ³ (wet weight)	Recommended Size Sample Container ⁴	Container Material ⁵	Preservative	Holding Time ⁶
Inorganics	5g	40g	4 oz	P or G	4°C	6 months
Mercury	2g	4g	4 oz	G	4°C	28 days
Cyanide	10g	40g	4 oz	P or G	4°C	14 days
Organotins	15g	20g	4 oz	G	4°C	7 days to extraction, 40 days until analysis
PCDDs/PCDFs	50g	40g	4 oz	G	4°C	30 days to extraction, 40 days until analysis
Semivolatile Organics	30g	20g	4 oz	G	4°C	7 days to extraction, 40 days until analysis
High Resolution PAHs	15g	20g	4 oz	G	4°C	7 days to extraction, 40 days until analysis
Pesticides/Aroclors PCBs	30g	120g	4 oz	G	4°C	7 days to extraction, 40 days until analysis
Coplanar PCBs	50g	120g	4 oz	G	4°C	7 days to extraction, 40 days until analysis
Chlorinated Herbicides	30g	120g	4 oz	G	4°C	7 days to extraction, 40 days until analysis
AVS/SEM	100g	120g	4 oz	G	4°C no headspace	7 days
TOC	20g	40g	4 oz	G	4°C	14 days
TEPH	20g	80g	4 oz	G	4°C	14 days to extraction, 40 days until analysis
Ammonia	25g	40g	4 oz	G	4°C	28 days
Grain size distribution ⁷	5g, 300g	40g	4 oz	G	4°C	7 days
Moisture Content	5g	40g	4 oz	G	4°C	7 days

Notes:

1 Analytical methods are specified in Table 7-1.

2 Minimal amount estimated to be necessary for laboratory analysis assuring minimal re-extraction or reparation requirements. Minimum dry weights provided by Environmental Data Services, March 2000.

3 Samples for analyses having identical container and preservation requirements may be combined in the same container.

4 Wide-mouth jars with Teflon-lined lids preferred.

5 P = plastic (polyethylene), G = amber glass.

6 Holding time is calculated from the date of sample collection to the date of sample analysis (or extraction as noted).

7 Use of laser diffraction methodology for grain size analysis requires a minimum of 5 grams of solids dry weight. Use of standard ASTM method requires 300 grams.

82697101

Attachment 3

Two Tower Center Blvd.
10th Floor
East Brunswick, New Jersey 08816

CLH
CHEMICAL LAND HOLDINGS, INC.

July 21, 2000

Mr. Sheldon Lipke
Passaic Valley Sewerage Commissioners
600 Wilson Avenue
Newark, NJ 07105

Attention: Sheldon Lipke
Superintendent of Plant Operations

Subject: Chemical Land Holdings, Inc.
CSO Trial Run Recommendation Report

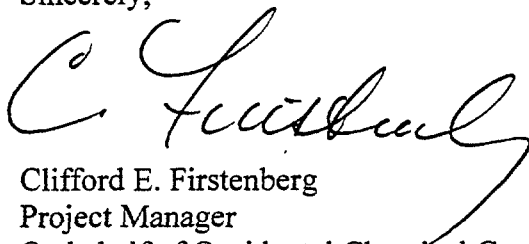
Dear Mr. Lipke:

At the request of Ms. Sharon Jaffess, United States Environmental Protection Agency (EPA), Chemical Land Holdings, Inc. (CLH) is providing you with a copy of the CSO Trial Run Recommendation Report, dated June 23, 2000. This report provides a summary of the CSO Trial Run Program (including associated analytical results), along with a discussion of the proposed Full-Scale CSO monitoring program. As agreed upon at our November 5, 1999 meeting, this memorandum was to be reviewed by EPA prior to its submittal to PVSC.

CLH is working with EPA to arrange a meeting to discuss implementation of the Full-Scale CSO sampling program. It is our understanding that Ms. Jaffess will be coordinating such a meeting in the very near future.

Please contact me with any questions.

Sincerely,




Clifford E. Firstenberg
Project Manager
On behalf of Occidental Chemical Corporation
(as successor to Diamond Shamrock Chemicals Corporation)

Enclosure (2 copies)

Copy to: B. McKenna, PVSC
Sharon Jaffess, USEPA (w/o enclosure)
Robert Romagnoli, P.E., Blasland, Bouck & Lee, Inc. (w/o enclosure)

Two Tower Center Blvd.
10th Floor
East Brunswick, New Jersey 08816


CHEMICAL LAND HOLDINGS, INC.

July 21, 2000

Environmental Defense
257 Park Avenue South
New York, NY 10010

Attention: James Tripp

Subject: Chemical Land Holdings, Inc.
CSO Trial Run Recommendation Report

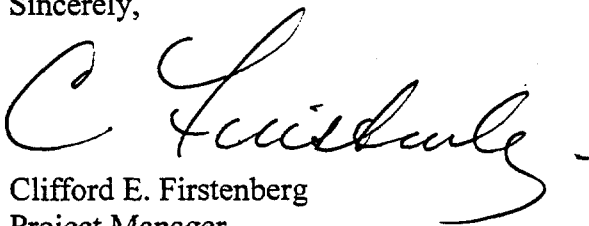
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Sincerely,



Clifford E. Firstenberg
Project Manager
On behalf of Occidental Chemical Corporation
(as successor to Diamond Shamrock Chemicals Corporation)

Enclosure (2 copies)

Copy to:

Sharon Jaffess, USEPA (w/o enclosure)

Two Tower Center Blvd.
10th Floor
East Brunswick, New Jersey 08816

FILE
CLH
CHEMICAL LAND HOLDINGS, INC.

July 21, 2000

Hudson River Foundation
40 West 20th Street, 9th Floor
New York, NY 10011-4211

Attention: Dennis Suskowski Ph. D.
Science Director

Subject: Chemical Land Holdings, Inc.
CSO Trial Run Recommendation Report

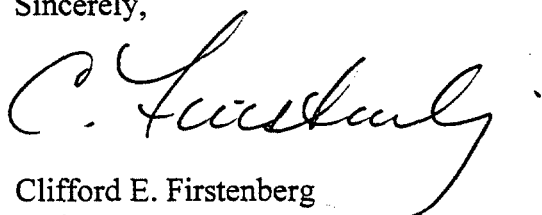
Dear Dr. Suskowski:

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Sincerely,



Clifford E. Firstenberg
Project Manager
On behalf of Occidental Chemical Corporation
(as successor to Diamond Shamrock Chemicals Corporation)

Enclosure (2 copies)

Copy to:

Sharon Jaffess, USEPA (w/o enclosure)

**SUMMARY OF CSO TRIAL RUN PROGRAM
AND FULL-SCALE RECOMMENDATION REPORT**
Passaic River Study Area
Administrative Order on Consent Index No. II-CERCLA-0117
June 2000

INTRODUCTION

Chemical Land Holdings, Inc. (CLH) recently completed the Trial Run Combined Sewer Overflow (CSO) sampling program at the Saybrook Place CSO located in Newark, New Jersey. This program was conducted under the auspices of the United States Environmental Protection Agency (EPA)-approved Ecological Sampling Plan (ESP, March 1999). Results of the CSO Trial Run program, along with recommendations related to the execution of a Full-Scale CSO Sampling Program, are provided herein.

Specifically, this correspondence addresses the following:

- Overview of CSO Sampling Program;
- Trial Run Implementation;
- Data Considerations;
- Logistical Considerations;
- Proposed Full-Scale Program; and
- Potential Program Modifications.

A discussion of each of these items follows.

OVERVIEW OF CSO SAMPLING PROGRAM

The ESP identifies two sampling protocols for the collection of solids associated with Passaic River Study Area (Study Area) CSO discharges: Standard Operating Procedures (SOPs) 6 and 14.

- SOP 6 describes a sampling approach that involves the collection of CSO water (up to 400 gallons) followed by homogenization and collection of water and solids samples. Water samples are paired filtered and unfiltered liquid samples; solids are settleable and/or filtered solids from the 400 gallon water sample. This method will be referred to as the "bulk sampling" approach.
- SOP 14 involves the collection of solids using passive collection devices installed within the CSO chamber. This method will be referred to as the "sediment trap" approach.

Both SOPs specify automated monitoring of other CSO-related parameters including, but not limited to, flow and dissolved oxygen (DO).

According to the ESP, a Trial Run program was to be implemented to compare and assess both sampling methods. The results of this program were to be used to design a Full-Scale sampling approach. As outlined in the ESP, the Trial Run was to be conducted at one CSO discharge location considered generally representative of the entire CSO system. Specifically, the Trial Run included a 30-day period during which the sediment traps were to be installed and maintained at

**SUMMARY OF CSO TRIAL RUN PROGRAM
AND FULL-SCALE RECOMMENDATION REPORT**
Passaic River Study Area
Administrative Order on Consent Index No. II-CERCLA-0117
June 2000
(continued)

the selected CSO location. During this same period, and from the same CSO, a bulk sample was to be collected during a single overflow event.

TRIAL RUN IMPLEMENTATION

With one exception, the CSOs and related appurtenances within the Study Area are owned and operated by the Passaic Valley Sewerage Commissioners (PVSC). The City of Newark owns the Roanoke Avenue CSO. Prior to conducting the Trial Run, it was first necessary to obtain PVSC's permission to access the CSO network. This process was completed in November 1999. In parallel with access negotiations, retrieval and review of CSO-related information was performed to identify an appropriate Trial Run location. CLH selected the Saybrook Place CSO in downtown Newark (Figure 1).

The Trial Run was conducted from early December 1999 through early March 2000. At the start of the program, and in close coordination with PVSC, sampling equipment was mounted within the Saybrook Place CSO, including an automated sampler (to primarily measure flow and water depth) and sediment traps (Figure 2). As shown in Figure 2, a total of six sediment traps were installed within the chamber, four more than required by the ESP. CLH surmised that six traps would be better for evaluation of capture rates at various locations within the CSO structure. Additional monitoring/sampling equipment was utilized during actual sample collection procedures, as further described herein.

Concurrent with the sampling at Saybrook Place CSO, CLH conducted a reconnaissance of the remaining 28 CSOs to collect physical information and evaluate sampling logistics. This information was tabulated and summarized to support planning for the Full-Scale sampling program.

Sediment Traps

The sediment traps were deployed on December 8, 1999 and retrieved on January 12, 2000, providing a total exposure period of 36 days (this deployment period exceeded the 30-day requirement specified in the ESP). Upon retrieval, approximately 2 to 2 ½ inches of sediment were recovered from Trap 2, located in the middle of the CSO chamber (see Figure 2). Less than ½ inch of sediment was recovered from each of the remaining five traps. Recovered materials included black fine sand and fines, as well as food matter and floatables. A single composite sample was prepared for chemical analyses, and shipped to the ESP-approved laboratories.

To determine if "wash-out" was occurring in the sediment traps (i.e., loss of collected sediments due to higher flow events), and to collect additional sediment for grain size analysis, the six traps were re-deployed in mid-January 2000. During an inspection in mid-February, Trap 2 was found to have approximately 1¾ inches of sediment, while the remaining five had less than ½ inch of material.

**SUMMARY OF CSO TRIAL RUN PROGRAM
AND FULL-SCALE RECOMMENDATION REPORT**
Passaic River Study Area
Administrative Order on Consent Index No. II-CERCLA-0117
June 2000
(continued)

The sediment traps were retrieved at the end of the second deployment on March 2, 2000. At least one overflow event had occurred between the mid-February inspection and the retrieval date. Four of the traps (1, 2, 3, and 5) were found to have recovered 2 to 3 inches of sediment, while Trap 4 recovered one inch, and Trap 6 recovered 3 ¼ inches. Similar to the first deployment, recovered materials included black fine sand and fines, as well as food matter and floatables. A single composite sample was again prepared for laboratory submittal, this time for grain size analysis only.

Bulk Sampling

On January 4, 2000, the bulk water sample (400 gallons) was collected during an overflow event. In addition to collecting the water, measurements of pH, DO, and conductivity were obtained using manual probes. Flow was measured using the automated sampler. That same day, unfiltered aqueous samples were submitted to the approved laboratories for chemical analyses (including TSS). A filtered aqueous sample was obtained and submitted for chemical analyses the following day. (Note that, according to the ESP, the aqueous samples were to be analyzed only if sufficient solids were not collected from the tank. As indicated below, this was not the case. However, CLH chose to analyze the samples anyway.)

On January 7, 2000, water from the 400-gallon tank was filtered to obtain and analyze sediments contained within. The filters were submitted to the laboratories with the retained solids for chemical and physical (grain size) analyses. CLH also submitted an unused filter for chemical analyses to determine if, and to what extent, the filters themselves may affect the final results.

ASTM grain size analyses require more sediment than could readily be obtained from the filtered sample. Therefore, to provide a direct comparison between the distribution of grain sizes collected with each method, a different analytical technique was performed. Particle Technologies Laboratory (PTL, Downers Grove, IL) requires much less material, since it utilizes a laser diffraction methodology to measure the grain size fractions. On March 2, 2000, a subsequent round of filtered sediments were collected from the tank. These sediments, along with material obtained from the sediment traps on that same day, were sent to PTL for analysis.

Table 1 presents a summary of the bulk sampling and sediment trap samples collected, including descriptions of the media represented by each. Note that as part of the bulk sampling process, two equipment rinse blanks were obtained. The first (CSO00RB01) was collected from the decontaminated tank, filter plates, tubing, and spatulas. The second rinse blank (CSO00RB02) was obtained from a surrogate submersible pump and hose. Similar items had been installed and used to collect the bulk sample without prior decontamination. Therefore, this second rinse blank was collected to determine the impact (if any) of "off the shelf" equipment that was used without undergoing decontamination.

**SUMMARY OF CSO TRIAL RUN PROGRAM
AND FULL-SCALE RECOMMENDATION REPORT**
Passaic River Study Area
Administrative Order on Consent Index No. II-CERCLA-0117
June 2000
(continued)

DATA CONSIDERATIONS

The validated data from the Trial Run sampling event (Tables 2, 3, and 4) were used to evaluate the two sampling methodologies. The constituents (including dioxins/furans and PCBs) contained in the bulk sediment samples were detected at higher frequencies and concentrations compared to the solids collected from within the sediment traps. This observation is not unexpected given the grain size data presented in Attachment 1. As shown in the attachment, the "bulk" solids were shown to contain a higher fraction of fines relative to the sediment trap material.

Several of the bulk solids analyses generated relatively high detection limits. Based upon input from the laboratories, and CLH's data validator, Environmental Data Services, Ltd. (EDS), it is believed that this is a result of the relatively high moisture content found in the filters. CLH considered filter presses and air drying of the filters to remove excess moisture. However, the most promising approach seems to be an alternate solids separation technique (i.e., centrifuging).

Finally, the data indicate potential QA/QC issues associated with some of the sampling equipment and filters used in the bulk sampling procedures. However, only "valid" data have been considered in development of the recommendations. Additional useable data would have been available absent these QA/QC issues. As a result of this evaluation, "off the shelf" equipment will not be utilized without full decontamination, unless certified clean, as required for sample containers. Further, pending the results of CLH's evaluation of centrifugation to replace the filtration process, the impact of filter materials on the results of chemical analyses will be eliminated. Finally, recognizing that the Trial Run was implemented to "debug" the overall CSO Program, CLH will resample Saybrook Place as part of the Full-Scale operation.

LOGISTICAL CONSIDERATIONS

Logistical considerations affect the ability to conduct the sampling program and must be considered as part of the final recommendation. Factors such as manhole access, traffic, tidal influence, and potential for overflow are all important. Based upon the reconnaissance of the CSOs, along with data from other sources (i.e., the CSO plans provided by PVSC and various reports prepared by Killam Associates, PVSC's consultant), these factors are summarized in Table 5 for each CSO. The results of the reconnaissance are incorporated into the recommendations for the proposed Full-Scale program, below.

PROPOSED FULL-SCALE PROGRAM

Based upon the information presented above, CLH recommends that, overall, bulk sampling be employed as the primary sample collection methodology for the Full-Scale CSO program. For those CSOs where bulk sampling may be infeasible, sediment traps will be considered for use. However, due to the difference between analytical results derived from each of these methods,

**SUMMARY OF CSO TRIAL RUN PROGRAM
AND FULL-SCALE RECOMMENDATION REPORT
Passaic River Study Area
Administrative Order on Consent Index No. II-CERCLA-0117
June 2000
(continued)**

before the sediment traps are utilized exclusively for data collection, CLH believes that additional performance evaluation is necessary.

To aid in this evaluation, and for the purposes of implementing a more manageable program, CLH proposes that the Full-Scale operation be performed in stages. Therefore, each CSO has been segregated into a separate category, as described further below.

Category 1a

This category includes all of those CSOs where CLH believes the bulk sampling methodology (SOP 6) is readily implementable, including:

1. Worthington Avenue;
2. Herbert Place;
3. Middlesex Street;
4. Saybrook Place;
5. Dey Street;
6. Tappan Street;
7. Duke Street;
8. Rector Street;
9. Bergen Street; and
10. Ivy Street.

Utilizing the bulk sampling methodology, CLH proposes to initially sample the CSOs at Worthington Avenue and Herbert Place over the two required storm events (the ESP specifies that one dry weather and one wet weather event be monitored for each CSO). Upon evaluation of the logistics associated with this initial sampling phase, the remaining eight CSOs in Category 1a would then be sampled in groups of two to four according to the requirements of the ESP.

As part of this overall sampling effort, CLH also proposes to install sediment traps within each of the first five CSOs listed above (i.e., Worthington, Herbert, Middlesex, Saybrook, and Dey). According to available records, these five CSOs represent a relatively wide range of tidal influences. Information gathered from this effort will be used to further evaluate the trap performance. With PVSC's cooperation, CLH may request that the sediment traps remain in place beyond the time required to collect the two bulk samples, possibly as long as the four months specified in SOP 14. Unless the sediment trap data obtained from the first five CSOs reveal conclusions different than those obtained during the Trial Run, traps will not be installed within the latter five.

**SUMMARY OF CSO TRIAL RUN PROGRAM
AND FULL-SCALE RECOMMENDATION REPORT**
Passaic River Study Area
Administrative Order on Consent Index No. II-CERCLA-0117
June 2000
(continued)

Category 1b

This category includes 11 CSOs where, according to available information, bulk sampling may be more difficult to implement due to vehicular traffic and limited working areas. Therefore, CLH will require additional time to plan the sampling effort and coordinate with PVSC and/or local law enforcement for traffic control. This category includes the following 11 CSOs:

- 11. Clay Street;
- 12. Polk Street;
- 13. City Dock;
- 14. Harrison Avenue;
- 15. Fourth Avenue;
- 16. Johnston Avenue;
- 17. Passaic Street;
- 18. Central Avenue;
- 19. New Street;
- 20. Cleveland Avenue; and
- 21. Marshall Street.

If bulk sampling is not a feasible option at some or all of the Category 1b CSOs, then consideration will be given to the use of sediment traps (again utilizing whatever information is gathered during the first phase of work). Should bulk sampling be deemed feasible, the CSOs will be sampled in groups of three to four (maximum) per storm event following 1a sampling.

Category 2

The second category includes nine CSOs where available records indicate that overflow events do not occur; that the CSO is inactive; or that the CSO was not inspected during the initial reconnaissance effort (i.e., Roanoke Avenue). This category includes the following nine CSOs:

- 22. Roanoke Avenue;
- 23. Freeman Street;
- 24. Third Avenue;
- 25. Nairn Street;
- 26. Jackson Street;
- 27. Bergen Avenue (West);
- 28. Orange Street;
- 29. Bridge Street; and
- 30. Bergen Avenue (East).

For each of these CSOs, CLH will attempt to obtain additional information from PVSC to confirm whether overflow events do or do not occur. Should it be confirmed that overflow events do not

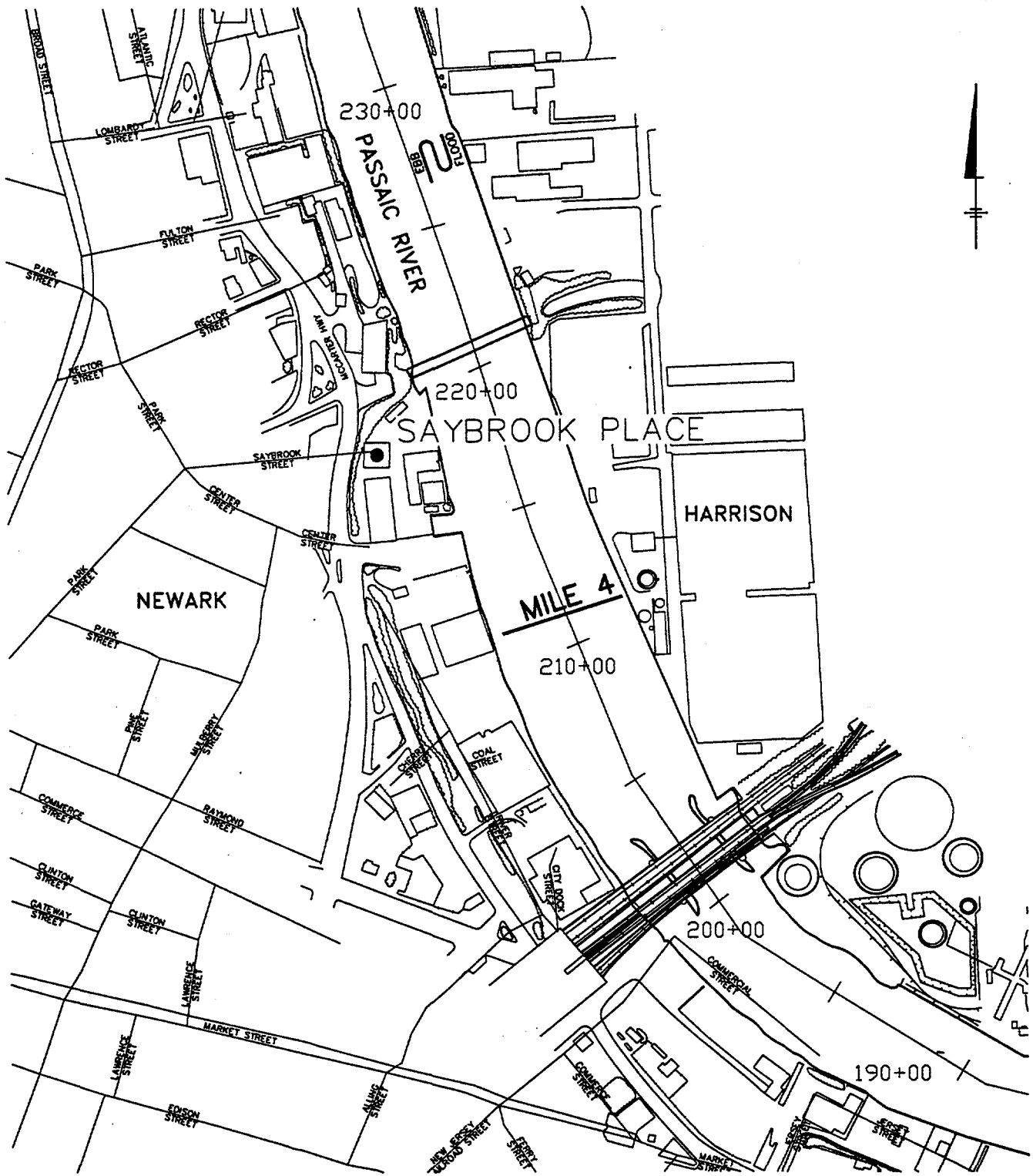
**SUMMARY OF CSO TRIAL RUN PROGRAM
AND FULL-SCALE RECOMMENDATION REPORT
Passaic River Study Area
Administrative Order on Consent Index No. II-CERCLA-0117
June 2000
(continued)**

occur at a specific CSO, it may be eliminated from consideration for sampling as part of the Full-Scale program. Conversely, should it be determined that overflow events do occur, that CSO will be evaluated for implementation of bulk sampling and placed within Category 1a or 1b, as appropriate.

POTENTIAL PROGRAM MODIFICATIONS

As indicated previously, CLH is considering modifying one or more techniques associated with the bulk sampling procedure.

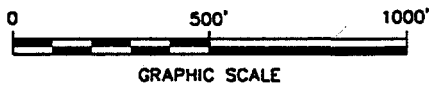
1. CLH is evaluating the use of a portable centrifuge to separate solids from the bulk water sample in lieu of filtration. A demonstration of a portable centrifuge was conducted, as well as a comparison of grain size distribution from a sample collected with the centrifuge versus a sample collected from the same tank of water using traditional filtration. Since the data have not been fully checked and analyzed, a recommendation is not included in this report. CLH will update EPA and PVSC on this evaluation during our meeting.
2. CLH is planning to analyze all water samples collected as part of the bulk sampling methodology (i.e., the filtered/unfiltered water samples). The ESP currently states that such samples would be analyzed only if sufficient solids were not collected through the filtering (or solids separation) process. CLH is prepared to perform the additional analyses to support this investigation, as well as other studies being performed by the PVSC, Harbor Estuary Program/Contaminant Assessment Reduction Program, etc.



LEGEND:

- SHORELINE
- ◻ CSO CHAMBER

SAYBROOK PLACE



GRAPHIC SCALE

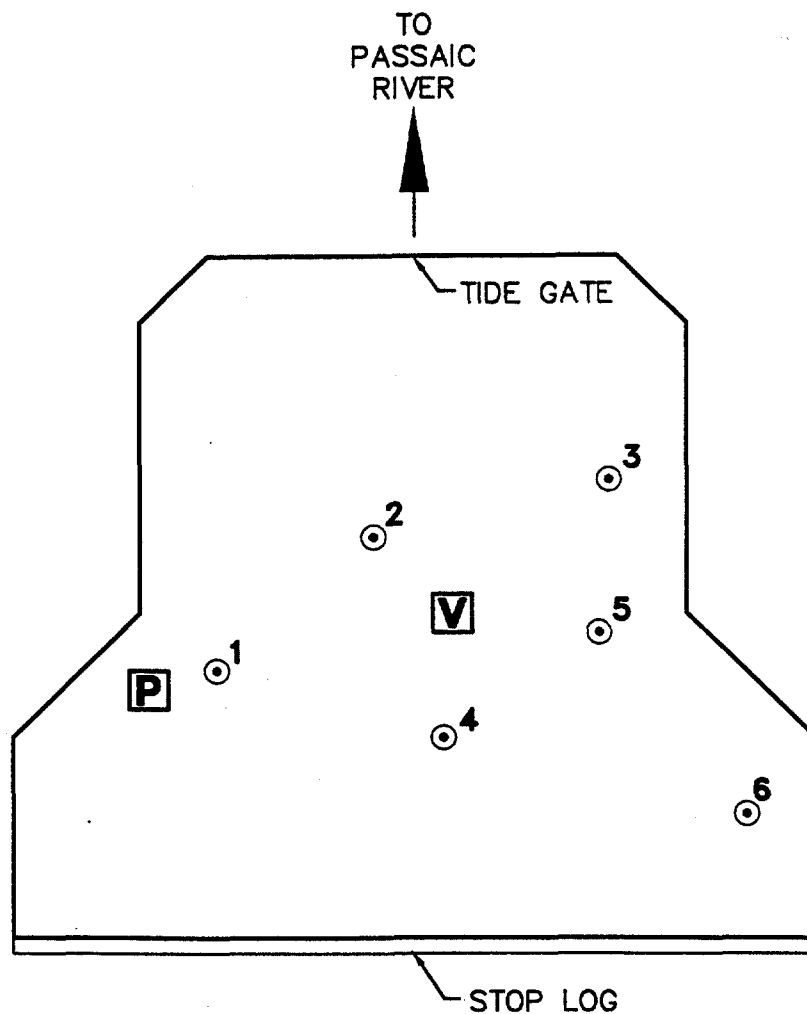
**SAYBROOK PLACE CSO
LOCATION**

FIGURE

1

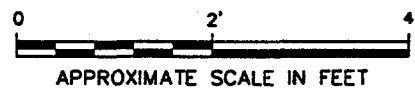
J994X01.DWG, 09994X02.DWG
L: ON=*, OFF=REF, IGRID
P: STD-PCP/AP
6/23/00 SYR-54-QMS LAS DCC
09994083/09994823.DWG

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LEGEND

- ⊙² SEDIMENT TRAP
- P** SUBMERSIBLE PUMP
- V** VELOCITY PROBE



**SAYBROOK PLACE CSO
EQUIPMENT LAYOUT**

FIGURE
2

X: NONE
L: OFF-REF
P: STD AP, PCP
JUNE 22, 2000 CRA-62-WON SYR-54-JER LAS
09994063\09994001.DWG

TABLE 1
CHEMICAL LAND HOLDINGS, INC.

CSO TRIAL RUN - SAMPLE SUMMARY

SDG #	SAMPLE #	MATRIX	DATE COLLECTED	FIELD SAMPLE	MS	MSD	DUPLICATE	RINSE BLANK	PERFORMANCE EVALUATION SAMPLE	COMMENTS
BULK SAMPLING METHODOLOGY										
CSO01	CSO00RB01	WATER	1/3/00					X		Rinse blank from decontaminated sampling equipment (tank, filter plates, tubing for pump and filter, spatulas)
	CSO00RB02	WATER	1/3/00					X		Rinse blank from unused (not decontaminated) equipment (submersible pump and hose)
	CSO0011CWUE-1	WATER	1/4/00	X	X	X				Unfiltered aqueous sample
	DCS0CWUE 1	WATER	1/4/00	X			X			Duplicate of CSO0011CWUE-1
	CSO0011CWUE02	WATER	1/4/00							TSS sample for sediment trap protocol sent to laboratory in multiple jars for flow-weighted compositing
CSO02	CSO0011CWFE-1	WATER	1/5/00	X	X	X				Filtered aqueous sample
	DCS0CWFE 1	WATER	1/5/00	X			X			Duplicate of CSO0011CWFE-1
CSO03	CSO0011SDFS01	FILTERED SEDIMENT	1/7/00	X	X	X				Filtered sediment (on filters)
	DCS0SDFS01	FILTERED SEDIMENT	1/7/00	X			X			Duplicate of CSO0011SDFS01
	CSO0011CF	UNUSED FILTERS	1/7/00	X						Sample of unused filters
	CSO0011SDFS02	FILTERED SEDIMENT	1/13/00	X						Filtered sediment (on filters) for grain size analysis
CSO04	CSO0011SDPE01	SOIL	1/7/00						X	Performance Evaluation Sample - unfortified
	CSO0011SDPE02	SOIL	1/7/00						X	Performance Evaluation Sample -fortified
CSO06	CSO0011SDFS03	FILTERED SEDIMENT	3/2/00	X						Filtered sediment samples for grain size analysis
SEDIMENT TRAP METHODOLOGY										
CSO05	CSO0011SDSS01	SEDIMENT	1/12/00	X						Sediment from sediment traps - insufficient mass for MS/MSD or Duplicate. Requested lab spike for QC.
CSO07	CSO0011SDSS02	SEDIMENT	3/2/00	X						Sediment from sediment traps for grain size analyses.

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TABLE 2
CHEMICAL LAND HOLDINGS, INC.

CSO TRIAL RUN SAMPLING (1/00)
SUMMARY OF SEDIMENT SAMPLE DATA

Analyte	Reporting Units	CSO0011SDFS01 Filtered Sediment	DCSOSDFS01 Filtered Sediment Dup.	CSO0011SDSS01 Sediment Trap
Semi-VOAs				
Phenol	ug/Kg	1900 UM	R	510 U
bis(2-Chloroethyl)ether	ug/Kg	1900 UM	R	510 U
2-Chlorophenol	ug/Kg	1900 UM	R	510 U
1,3-Dichlorobenzene	ug/Kg	1900 UM	R	510 U
1,4-Dichlorobenzene	ug/Kg	1900 UM	R	300 G
1,2-Dichlorobenzene	ug/Kg	1900 UM	R	510 U
2-Methylphenol	ug/Kg	1900 UM	R	510 U
2,2'-oxybis(1-Chloropropane)	ug/Kg	1900 UJ	R	510 U
4-Methylphenol	ug/Kg	1900 UM	R	140 G
N-Nitroso-di-n-propylamine	ug/Kg	1900 UM	R	510 U
Hexachloroethane	ug/Kg	1900 UM	R	510 U
Nitrobenzene	ug/Kg	1900 UM	R	510 U
Isophorone	ug/Kg	1900 UM	R	510 U
2-Nitrophenol	ug/Kg	1900 UM	R	510 U
2,4-Dimethylphenol	ug/Kg	1900 UM	R	510 U
bis(2-Chloroethoxy)methane	ug/Kg	1900 UM	R	510 U
2,4-Dichlorophenol	ug/Kg	1900 UM	R	510 U
1,2,4-Trichlorobenzene	ug/Kg	1900 UM	R	510 U
Naphthalene	ug/Kg	1900 UM	R	55 G
4-Chloroaniline	ug/Kg	1900 UM	R	510 U
Hexachlorobutadiene	ug/Kg	1900 UM	R	510 U
4-Chloro-3-methylphenol	ug/Kg	1900 UM	R	510 U
2-Methylnaphthalene	ug/Kg	1900 UM	R	510 U
Hexachlorocyclopentadiene	ug/Kg	3900 UM	R	1000 U
2,4,6-Trichlorophenol	ug/Kg	1900 UM	R	510 U
2,4,5-Trichlorophenol	ug/Kg	1900 UM	R	510 U
2-Chloronaphthalene	ug/Kg	1900 UM	R	510 U
2-Nitroaniline	ug/Kg	1900 UM	R	510 U
Dimethylphthalate	ug/Kg	1900 UM	R	510 U
Acenaphthylene	ug/Kg	1900 UM	R	510 U
3-Nitroaniline	ug/Kg	1900 UM	R	510 U
Acenaphthene	ug/Kg	1900 UM	R	94 G
2,4-Dinitrophenol	ug/Kg	11000 UM	R	3100 U
4-Nitrophenol	ug/Kg	4900 UM	R	1300 U
Dibenzofuran	ug/Kg	1900 UM	R	73 G
2,4-Dinitrotoluene	ug/Kg	1900 UM	R	510 U
2,6-Dinitrotoluene	ug/Kg	1900 UM	R	510 U
Diethylphthalate	ug/Kg	1900 UM	R	510 U
4-Chlorophenyl-phenylether	ug/Kg	1900 UM	R	510 U
Fluorene	ug/Kg	1900 UM	R	110 G

(See Data Qualifier Sheet for explanation of data qualifiers)

TABLE 2
CHEMICAL LAND HOLDINGS, INC.

CSO TRIAL RUN SAMPLING (1/00)
SUMMARY OF SEDIMENT SAMPLE DATA

Analyte	Reporting Units	CSO0011SDFS01 Filtered Sediment	DCSOSDFS01 Filtered Sediment Dup.	CSO0011SDSS01 Sediment Trap
Semi-VOAs (Continued)				
4-Nitroaniline	ug/Kg	1900 UM	R	510 U
4,6-Dinitro-2-methylphenol	ug/Kg	4900 UM	R	1300 U
N-Nitrosodiphenylamine	ug/Kg	1900 UM	R	510 U
4-Bromophenyl-phenylether	ug/Kg	1900 UM	R	510 U
Hexachlorobenzene	ug/Kg	1900 UM	R	510 U
Pentachlorophenol	ug/Kg	4900 UM	R	1300 U
Phenanthrene	ug/Kg	400 GM	R	1400
Anthracene	ug/Kg	1900 UM	R	250 G
Carbazole	ug/Kg	1900 UM	R	160 G
Di-n-butylphthalate	ug/Kg	1900 UM	R	810
Fluoranthene	ug/Kg	840 GM	R	1800
Pyrene	ug/Kg	780 GM	R	1700
Butylbenzylphthalate	ug/Kg	510 GM	R	620
3,3'-Dichlorobenzidine	ug/Kg	3900 UM	R	1000 U
Benzo(a)anthracene	ug/Kg	260 GM	R	800
bis(2-Ethylhexyl)phthalate	ug/Kg	5400 M	R	3000
Chrysene	ug/Kg	450 GM	R	970
Di-n-octylphthalate	ug/Kg	520 GM	R	160 G
Benzo(b)fluoranthene	ug/Kg	530 GM	R	1100
Benzo(k)fluoranthene	ug/Kg	210 GM	R	420 G
Benzo(a)pyrene	ug/Kg	310 GM	R	740
Indeno(1,2,3-cd)pyrene	ug/Kg	290 GM	R	550
Dibenz(a,h)anthracene	ug/Kg	1900 UM	R	140 G
Benzo(g,h,i)perylene	ug/Kg	310 GM	R	480 G
Pesticides/PCB Aroclors				
Alpha BHC	ug/Kg	16 UM	UR	52 UJ
Beta BHC	ug/Kg	16 UM	R	52 UJ
Delta BHC	ug/Kg	16 UM	R	52 U
Gamma BHC - Lindane	ug/Kg	16 UM	R	5.9 GJ
Heptachlor	ug/Kg	16 UM	R	52 U
Aldrin	ug/Kg	16 UM	R	52 U
Heptachlor Epoxide	ug/Kg	16 UM	R	52 U
Endosulfan I	ug/Kg	16 UM	R	52 U
Dieldrin	ug/Kg	31 UM	R	100 U
DDE	ug/Kg	31 UM	R	100 U
Endrin	ug/Kg	13 GM	R	6.7 GJ
Endosulfan II	ug/Kg	3.9 GM	R	100 UJ
DDD	ug/Kg	31 UJ	R	100 U
Endosulfan Sulfate	ug/Kg	31 UJ	R	100 U

(See Data Qualifier Sheet for explanation of data qualifiers)

TABLE 2
CHEMICAL LAND HOLDINGS, INC.

CSO TRIAL RUN SAMPLING (1/00)
SUMMARY OF SEDIMENT SAMPLE DATA

Analyte	Reporting Units	CSO0011SDFS01 Filtered Sediment	DCS0SDFS01 Filtered Sediment Dup.	CSO0011SDSS01 Sediment Trap
Pesticides/PCB Aroclors (Continued)				
DDT	ug/Kg	31 UJ	R	100 UJ
Endrin Ketone	ug/Kg	31 UJ	R	100 U
Methoxychlor	ug/Kg	160 UJ	R	520 UJ
Alpha Chlordane	ug/Kg	16 UM	R	52 U
Gamma Chlordane	ug/Kg	16 UJ	R	52 U
Toxaphene	ug/Kg	1600 UM	R	5200 U
Endrin Aldehyde	ug/Kg	31 UM	R	100 UJ
PCB-1016	ug/Kg	310 UM	R	1000 U
PCB-1221	ug/Kg	310 UM	R	1000 U
PCB-1232	ug/Kg	310 UM	R	1000 U
PCB-1242	ug/Kg	310 UM	R	1000 U
PCB-1248	ug/Kg	310 UM	R	1000 U
PCB-1254	ug/Kg	310 UM	R	1000 U
PCB-1260	ug/Kg	310 UM	R	1000 U
Herbicides				
2,4-D	ug/Kg	2300 UM	R	370 U
2,4,5-TP (Silvex)	ug/Kg	950 UM	R	150 U
2,4,5-T	ug/Kg	950 UM	R	150 U
2,4-DB	ug/Kg	R	R	280 U
Dioxin/Furan				
2,3,7,8-TCDD	ng/Kg	3.71	R	1.66 UJ
1,2,3,7,8-PeCDD	ng/Kg	9.26	5.82 J	1.75 UJ
1,2,3,4,7,8-HxCDD	ng/Kg	11.7 J	8.90 J	2.27 UJ
1,2,3,6,7,8-HxCDD	ng/Kg	28.8 J	23.6 J	2.55 UJ
1,2,3,7,8,9-HxCDD	ng/Kg	18.9 J	16.3 J	2.24 UJ
1,2,3,4,6,7,8-HpCDD	ng/Kg	610	490 J	26.3 J
OCDD	ng/Kg	6730	5310 J	245 J
2,3,7,8-TCDF	ng/Kg	12.4	9.65	1.39 UJ
1,2,3,7,8-PeCDF	ng/Kg	6.01	R	3.06 UJ
2,3,4,7,8-PeCDF	ng/Kg	13.0	10.6 J	2.20 UJ
1,2,3,4,7,8-HxCDF	ng/Kg	18.9 J	15.7 J	1.57 UJ
1,2,3,6,7,8-HxCDF	ng/Kg	15.0 J	14.2 J	1.58 UJ
2,3,4,6,7,8-HxCDF	ng/Kg	13.1 J	12.6 J	0.491 UJ
1,2,3,7,8,9-HxCDF	ng/Kg	3.21 U	R	0.889 UJ
1,2,3,4,6,7,8-HpCDF	ng/Kg	199	174 J	7.66 J
1,2,3,4,7,8,9-HpCDF	ng/Kg	12.2	R	0.761 UJ
OCDF	ng/Kg	427	294 J	16.6 J

(See Data Qualifier Sheet for explanation of data qualifiers)

TABLE 2
CHEMICAL LAND HOLDINGS, INC.

CSO TRIAL RUN SAMPLING (1/00)
SUMMARY OF SEDIMENT SAMPLE DATA

Analyte	Reporting Units	CSO0011SDFS01 Filtered Sediment	DCSOSDFS01 Filtered Sediment Dup.	CSO0011SDSS01 Sediment Trap
PCB Congeners				
PCB-1	ng/Kg	4260 UJ	3260 UJ	481 U
PCB-3	ng/Kg	4260 UJ	3260 UJ	481 U
PCB-8	ng/Kg	42600 UJ	32600 UJ	4810 U
PCB-15	ng/Kg	42600 UJ	32600 UJ	4810 U
PCB-18	ng/Kg	4260 UJ	3260 UJ	R
PCB-28	ng/Kg	4260 UJ	3260 UJ	R
PCB-44	ng/Kg	5080 J	4240 J	481 UJ
PCB-52	ng/Kg	5920 J	5440 J	499 J
PCB-66	ng/Kg	6050 J	5140 J	481 UJ
PCB-77	ng/Kg	4260 UJ	3260 UJ	481 UJ
PCB-81	ng/Kg	4260 UJ	3260 UJ	481 UJ
PCB-87	ng/Kg	11400 J	10300 J	913
PCB-90/101	ng/Kg	19600 J	17800 J	1680
PCB-118	ng/Kg	22100 J	19300 J	1050
PCB-123	ng/Kg	4260 UJ	3260 UJ	481 U
PCB-105	ng/Kg	10400 J	8730 J	481 U
PCB-114	ng/Kg	4260 UJ	3260 UJ	481 U
PCB-126	ng/Kg	4260 UJ	3260 UJ	481 U
PCB-128	ng/Kg	8040 J	6700 J	481 U
PCB-138	ng/Kg	38200 J	31800 J	2740
PCB-153	ng/Kg	25600 J	20700 J	1860
PCB-167	ng/Kg	4260 UJ	3260 UJ	481 U
PCB-156	ng/Kg	4260 UJ	3410 J	481 U
PCB-157	ng/Kg	4260 UJ	3260 UJ	481 U
PCB-169	ng/Kg	4260 UJ	3260 UJ	481 U
PCB-170	ng/Kg	9850 J	8150 J	786
PCB-180	ng/Kg	23100 J	18500 J	2030
PCB-183	ng/Kg	5410 J	4010 J	481 U
PCB-184	ng/Kg	4260 UJ	3260 UJ	481 U
PCB-187	ng/Kg	17500 J	12300 J	1200
PCB-189	ng/Kg	4260 UJ	3260 UJ	481 U
PCB-202	ng/Kg	19200 J	5180 J	847
PCB-194	ng/Kg	14600 J	8220 J	731
PCB-195	ng/Kg	4260 UJ	3260 UJ	481 U
PCB-206	ng/Kg	171000 J	36100 J	3240
PCB-207	ng/Kg	12000 J	3260 UJ	481 U
PCB-209	ng/Kg	41800 J	7160 J	671

(See Data Qualifier Sheet for explanation of data qualifiers)

TABLE 2
CHEMICAL LAND HOLDINGS, INC.

CSO TRIAL RUN SAMPLING (1/00)
SUMMARY OF SEDIMENT SAMPLE DATA

Analyte	Reporting Units	CSO0011SDFS01 Filtered Sediment	DCSOSDFS01 Filtered Sediment Dup.	CSO0011SDSS01 Sediment Trap
Inorganics				
Aluminum	mg/Kg	R	R	2580
Antimony	mg/Kg	1.0 BM	R	8.1 B
Arsenic	mg/Kg	0.84 BM	R	0.65 B
Barium	mg/Kg	R	R	27.4 B
Beryllium	mg/Kg	0.21 BM	R	0.15 B
Cadmium	mg/Kg	0.079 BM	R	0.045 U
Calcium	mg/Kg	R	R	4560 *
Chromium	mg/Kg	R	R	14.4
Cobalt	mg/Kg	4.5 BM	R	3.5 B
Copper	mg/Kg	51.6 *NJH	R	101 N*JL
Iron	mg/Kg	2990 *M	R	7280 *
Lead	mg/Kg	55.2 *M	R	55.0 *
Magnesium	mg/Kg	1310 M	R	1410
Manganese	mg/Kg	42.5 *M	R	86.1 NJL
Mercury	mg/Kg	0.32 M	R	0.14 *J
Nickel	mg/Kg	5.6 J	R	8.5
Potassium	mg/Kg	R	R	299 BNJH
Selenium	mg/Kg	0.33 UM	R	0.64 BJH
Silver	mg/Kg	1.7 M	R	4.0 *
Sodium	mg/Kg	R	R	283 BNJL
Thallium	mg/Kg	0.74 BM	R	0.76 U
Vanadium	mg/Kg	6.4 M	R	9.0
Zinc	mg/Kg	R	R	163 N*JL
Organotin				
Monobutyltin	ug Sn/Kg	25.6 UJ	24.0 UJ	R
Dibutyltin	ug Sn/Kg	51.1 UJ	19.9 UJ	8.42 J
Tributyltin	ug Sn/Kg	11.3 UJ	23.1 UJ	UR
Tetrabutyltin	ug Sn/Kg	1.00 UJ	1.00 UJ	R

(See Data Qualifier Sheet for explanation of data qualifiers)

TABLE 3
CHEMICAL LAND HOLDINGS, INC.

CSO TRIAL RUN SAMPLING (1/00)
SUMMARY OF WATER SAMPLE DATA

Analyte	Reporting Units	CSO0011CWFE-1 Filtered Water	DCSOCWFE-1 Filtered Water Dup.	CSO0011CWUE-1 Unfiltered Water	DCSOCWUE-1 Unfiltered Water Dup.	CSO00RB01 Rinse Blank	CSO00RB02 Rinse Blank
Semi-VOAs							
Phenol	ug/L	10 U	11 U	10 U	10 U	100 U	46
bis(2-Chloroethyl)ether	ug/L	10 U	11 U	10 U	10 U	100 U	10 U
2-Chlorophenol	ug/L	10 U	11 U	10 U	10 U	100 U	10 U
1,3-Dichlorobenzene	ug/L	10 U	11 U	10 U	10 U	100 U	10 U
1,4-Dichlorobenzene	ug/L	10 U	11 U	10 U	10 U	100 U	10 U
1,2-Dichlorobenzene	ug/L	10 U	11 U	10 U	10 U	100 U	10 U
2-Methylphenol	ug/L	10 U	11 U	10 U	10 U	100 U	10 U
2,2'-oxybis(1-Chloropropane)	ug/L	10 U	11 U	10 U	10 U	100 U	10 U
4-Methylphenol	ug/L	10 U	11 U	10 U	10 U	100 U	10 U
N-Nitroso-di-n-propylamine	ug/L	10 U	11 U	10 U	10 U	100 U	10 U
Hexachloroethane	ug/L	10 U	11 U	10 U	10 U	100 U	10 U
Nitrobenzene	ug/L	10 U	11 U	10 U	10 U	100 U	10 U
Isophorone	ug/L	10 U	11 U	10 U	10 U	100 U	10 U
2-Nitrophenol	ug/L	10 U	11 U	10 U	10 U	100 U	10 U
2,4-Dimethylphenol	ug/L	10 U	11 U	10 U	10 U	100 U	10 U
bis(2-Chloroethoxy)methane	ug/L	10 U	11 U	10 U	10 U	100 U	10 U
2,4-Dichlorophenol	ug/L	10 U	11 U	10 U	10 U	100 U	10 U
1,2,4-Trichlorobenzene	ug/L	10 U	11 U	10 U	10 U	100 U	10 U
Naphthalene	ug/L	10 U	11 U	10 U	10 U	100 U	10 U
4-Chloroaniline	ug/L	10 U	11 U	10 U	10 U	100 U	10 U
Hexachlorobutadiene	ug/L	10 U	11 U	10 U	10 U	100 U	10 U
4-Chloro-3-methylphenol	ug/L	10 U	11 U	10 U	10 U	100 U	10 U
2-Methylnaphthalene	ug/L	10 U	11 U	10 U	10 U	100 U	10 U
Hexachlorocyclopentadiene	ug/L	25 U	28 U	25 U	25 U	250 U	25 U
2,4,6-Trichlorophenol	ug/L	10 U	11 U	10 U	10 U	100 U	10 U
2,4,5-Trichlorophenol	ug/L	10 U	11 U	10 U	10 U	100 U	10 U
2-Chloronaphthalene	ug/L	10 U	11 U	10 U	10 U	100 U	10 U
2-Nitroaniline	ug/L	10 U	11 U	10 U	10 U	100 U	10 U
Dimethylphthalate	ug/L	10 U	11 U	10 U	10 U	100 U	10 U
Acenaphthylene	ug/L	10 U	11 U	10 U	10 U	100 U	10 U
3-Nitroaniline	ug/L	10 U	11 U	10 U	10 U	100 U	10 U
Acenaphthene	ug/L	10 U	11 U	10 U	10 U	100 U	10 U

(See Data Qualifier Sheet for explanation of data qualifiers)

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TABLE 3
CHEMICAL LAND HOLDINGS, INC.

CSO TRIAL RUN SAMPLING (1/00)
SUMMARY OF WATER SAMPLE DATA

Analyte	Reporting Units	CSO0011CWFE-1 Filtered Water	DCSOCWFE-1 Filtered Water Dup.	CSO0011CWUE-1 Unfiltered Water	DCSOCWUE-1 Unfiltered Water Dup.	CSO00RB01 Rinse Blank	CSO00RB02 Rinse Blank
Semi-VOAs (Continued)							
2,4-Dinitrophenol	ug/L	60 U	67 U	60 U	60 U	600 U	61 U
4-Nitrophenol	ug/L	50 U	56 U	50 U	50 U	500 U	51 U
Dibenzofuran	ug/L	10 U	11 U	10 U	10 U	100 U	10 U
2,4-Dinitrotoluene	ug/L	10 U	11 U	10 U	10 U	100 U	10 U
2,6-Dinitrotoluene	ug/L	10 U	11 U	10 U	10 U	100 U	10 U
Diethylphthalate	ug/L	10 U	11 U	10 U	10 U	100 U	10 U
4-Chlorophenyl-phenylether	ug/L	10 U	11 U	10 U	10 U	100 U	10 U
Fluorene	ug/L	10 U	11 U	10 U	10 U	100 U	10 U
4-Nitroaniline	ug/L	10 U	11 U	10 U	10 U	100 U	10 U
4,6-Dinitro-2-methylphenol	ug/L	25 U	28 U	25 U	25 U	250 U	25 U
N-Nitrosodiphenylamine	ug/L	10 U	11 U	10 U	10 U	100 U	10 U
4-Bromophenyl-phenylether	ug/L	10 U	11 U	10 U	10 U	100 U	10 U
Hexachlorobenzene	ug/L	10 U	11 U	10 U	10 U	100 U	10 U
Pentachlorophenol	ug/L	25 U	28 U	25 U	25 U	250 U	25 U
Phenanthrene	ug/L	10 U	11 U	1.0 G	1.0 G	100 U	10 U
Anthracene	ug/L	10 U	11 U	10 U	10 U	100 U	10 U
Carbazole	ug/L	10 U	11 U	10 U	10 U	100 U	10 U
Di-n-butylphthalate	ug/L	10 U	11 U	10 U	10 U	100 U	10 U
Fluoranthene	ug/L	10 U	11 U	2.0 G	2.0 G	100 U	10 U
Pyrene	ug/L	10 U	11 U	2.0 G	1.0 G	100 U	10 U
Butylbenzylphthalate	ug/L	10 U	11 U	2.0 G	2.0 G	100 U	10 U
3,3'-Dichlorobenzidine	ug/L	10 U	11 U	10 U	10 U	100 U	10 U
Benzo(a)anthracene	ug/L	10 U	11 U	10 U	10 U	100 U	10 U
bis(2-Ethylhexyl)phthalate	ug/L	10 U	11 U	15 U	14 U	100 U	15
Chrysene	ug/L	10 U	11 U	10 U	10 U	100 U	10 U
Di-n-octylphthalate	ug/L	10 U	11 U	10 U	10 U	100 U	10 U
Benzo(b)fluoranthene	ug/L	10 U	11 U	1.0 G	1.0 G	100 U	10 U
Benzo(k)fluoranthene	ug/L	10 U	11 U	10 U	10 U	100 U	10 U
Benzo(a)pyrene	ug/L	10 U	11 U	10 U	10 U	100 U	10 U
Indeno(1,2,3-cd)pyrene	ug/L	10 U	11 U	10 U	10 U	100 U	10 U
Dibenz(a,h)anthracene	ug/L	10 U	11 U	10 U	10 U	100 U	10 U
Benzo(g,h,i)perylene	ug/L	10 U	11 U	10 U	10 U	100 U	10 U

(See Data Qualifier Sheet for explanation of data qualifiers)

56901819.xls

TABLE 3
CHEMICAL LAND HOLDINGS, INC.

CSO TRIAL RUN SAMPLING (1/00)
SUMMARY OF WATER SAMPLE DATA

Analyte	Reporting Units	CSO0011CWFE-1 Filtered Water	DCSOCWFE-1 Filtered Water Dup.	CSO0011CWUE-1 Unfiltered Water	DCSOCWUE-1 Unfiltered Water Dup.	CSO00RB01 Rinse Blank	CSO00RB02 Rinse Blank
Pesticides/PCBs							
Alpha BHC	ug/L	0.050 UJ	0.050 UJ	0.050 UJ	0.050 UJ	0.0052 G	0.010 G
Beta BHC	ug/L	0.050 UJ	0.050 UJ	0.050 UJ	0.050 UJ	0.050 U	0.050 U
Delta BHC	ug/L	0.050 UJ	0.050 UJ	0.050 UJ	0.050 UJ	0.050 U	0.050 U
Gamma BHC - Lindane	ug/L	0.050 UJ	0.050 UJ	0.050 UJ	0.050 UJ	0.050 U	0.050 U
Heptachlor	ug/L	0.050 UJ	0.050 UJ	0.050 UJ	0.050 UJ	0.014 G	0.050 U
Aldrin	ug/L	0.050 UJ	0.050 UJ	0.050 UJ	0.050 UJ	0.050 U	0.050 U
Heptachlor Epoxide	ug/L	0.050 UJ	0.050 UJ	0.050 UJ	0.050 UJ	0.050 U	0.050 U
Endosulfan I	ug/L	0.050 UJ	0.050 UJ	0.019 GJ	0.020 GJ	0.050 U	0.050 U
Dieldrin	ug/L	0.10 UJ	0.10 UJ	0.10 UJ	0.10 UJ	0.10 U	0.10 U
DDE	ug/L	0.10 UJ	0.10 UJ	0.10 UJ	0.10 UJ	0.10 U	0.10 U
Endrin	ug/L	0.10 UJ	0.10 UJ	0.023 GJ	0.022 GJ	0.10 U	0.10 U
Endosulfan II	ug/L	0.10 UJ	0.10 UJ	0.10 UJ	0.10 UJ	0.10 U	0.10 U
DDD	ug/L	0.10 UJ	0.10 UJ	0.10 UJ	0.10 UJ	0.10 U	0.10 U
Endosulfan Sulfate	ug/L	0.10 UJ	0.10 UJ	0.10 UJ	0.10 UJ	0.020 G	0.10 U
DDT	ug/L	0.10 UJ	0.10 UJ	0.10 UJ	0.10 UJ	0.10 UJ	0.10 UJ
Endrin Ketone	ug/L	0.10 UJ	0.10 UJ	0.10 UJ	0.10 UJ	0.10 UJ	0.10 UJ
Methoxychlor	ug/L	0.50 UJ	0.50 UJ	0.50 UJ	0.50 UJ	0.50 UJ	0.50 UJ
Alpha Chlordane	ug/L	0.050 UJ	0.050 UJ	0.050 UJ	0.050 UJ	0.050 U	0.050 U
Gamma Chlordane	ug/L	0.050 UJ	0.050 UJ	0.050 UJ	0.050 UJ	0.050 U	0.050 U
Toxaphene	ug/L	5.0 UJ	5.0 UJ	5.0 UJ	5.0 UJ	5.0 U	5.0 U
Endrin Aldehyde	ug/L	0.10 UJ	0.10 UJ	0.10 UJ	0.10 UJ	0.10 U	0.10 U
PCB-1016	ug/L	1.0 UJ	1.0 UJ	1.0 UJ	1.0 UJ	1.0 U	1.0 U
PCB-1221	ug/L	1.0 UJ	1.0 UJ	1.0 UJ	1.0 UJ	1.0 U	1.0 U
PCB-1232	ug/L	1.0 UJ	1.0 UJ	1.0 UJ	1.0 UJ	1.0 U	1.0 U
PCB-1242	ug/L	1.0 UJ	1.0 UJ	1.0 UJ	1.0 UJ	1.0 U	1.0 U
PCB-1248	ug/L	1.0 UJ	1.0 UJ	1.0 UJ	1.0 UJ	1.0 U	1.0 U
PCB-1254	ug/L	1.0 UJ	1.0 UJ	1.0 UJ	1.0 UJ	1.0 U	1.0 U
PCB-1260	ug/L	1.0 UJ	1.0 UJ	1.0 UJ	1.0 UJ	1.0 U	1.0 U

TABLE 3
CHEMICAL LAND HOLDINGS, INC.

CSO TRIAL RUN SAMPLING (1/00)
SUMMARY OF WATER SAMPLE DATA

Analyte	Reporting Units	CSO0011CWFE-1 Filtered Water	DCSOCWFE-1 Filtered Water Dup.	CSO0011CWUE-1 Unfiltered Water	DCSOCWUE-1 Unfiltered Water Dup.	CSO00RB01 Rinse Blank	CSO00RB02 Rinse Blank
Herbicides							
2,4-D	ug/L	12 U	12 U	12 U	12 U	12 U	12 U
2,4,5-TP (Silvex)	ug/L	5.0 U	5.0 U	5.0 U	5.0 U	R	5.0 U
2,4,5-T	ug/L	5.0 U	5.0 U	R	R	5.0 U	5.0 U
2,4-DB	ug/L	R	9.1 UJ	9.1 UJ	9.1 UJ	9.1 UJ	9.1 UJ
Dioxin/Furan							
2,3,7,8-TCDD	pg/L	3.57 U	4.09 U	3.02 U	3.83 U	7.61 U	8.53 U
1,2,3,7,8-PeCDD	pg/L	3.76 U	5.24 U	5.15 U	4.95 U	10.1 U	16.3 U
1,2,3,4,7,8-HxCDD	pg/L	4.24 U	6.65 U	6.91 U	6.72 U	15.6 U	15.8 U
1,2,3,6,7,8-HxCDD	pg/L	4.74 U	7.41 U	9.02 U	9.56 U	17.1 U	18.1 U
1,2,3,7,8,9-HxCDD	pg/L	4.18 U	6.54 U	7.33 U	7.45 U	15.2 U	15.8 U
1,2,3,4,6,7,8-HpCDD	pg/L	7.99 U	8.05 U	130	127	13.2 U	59.3
OCDD	pg/L	40.9	44.6	1460	1400	36.6 U	137
2,3,7,8-TCDF	pg/L	1.50 U	1.66 U	2.40 U	2.78 U	3.90 U	9.09 U
1,2,3,7,8-PeCDF	pg/L	7.01 U	6.53 U	2.36 U	2.72 U	14.8 U	17.6 U
2,3,4,7,8-PeCDF	pg/L	5.30 U	4.75 U	6.41 U	3.94 U	10.4 U	19.7
1,2,3,4,7,8-HxCDF	pg/L	2.41 U	4.42 U	5.00 U	5.22 U	8.63 U	59.1
1,2,3,6,7,8-HxCDF	pg/L	2.37 U	4.21 U	5.18 U	4.73 U	9.14 U	35.9
2,3,4,6,7,8-HxCDF	pg/L	1.77 U	3.11 U	3.99 U	2.97 U	6.09 U	11.5
1,2,3,7,8,9-HxCDF	pg/L	2.96 U	5.74 U	3.81 U	1.61 U	9.70 U	7.88 U
1,2,3,4,6,7,8-HpCDF	pg/L	4.23 U	5.16 U	50.7	53.6	10.1 U	192
1,2,3,4,7,8,9-HpCDF	pg/L	6.83 U	9.34 U	5.75 U	3.68 U	18.5 U	15.3 U
OCDF	pg/L	11.3 U	22.3 U	101	98.2	31.7 U	291
PCB Congeners							
PCB-1	pg/L	1040 UJ	995 UJ	993 UJ	R	3330 UJ	3330 UJ
PCB-3	pg/L	1040 UJ	995 UJ	993 UJ	R	3330 UJ	6260 J
PCB-8	pg/L	10400 UJ	9950 UJ	9930 UJ	R	33300 UJ	33300 UJ
PCB-15	pg/L	10400 UJ	9950 UJ	9930 UJ	R	33300 UJ	33300 UJ
PCB-18	pg/L	R	995 UJ	1280 J	1260 J	R	3500 J
PCB-28	pg/L	R	995 UJ	2020 J	1520 J	R	R
PCB-44	pg/L	1040 UJ	995 UJ	2550 J	2290 J	3330 UJ	5920 J
PCB-52	pg/L	1040 UJ	995 UJ	2990 J	2940 J	3330 UJ	6530 J
PCB-66	pg/L	1040 UJ	995 UJ	2610 J	2530 J	3330 UJ	7480 J

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TABLE 3
CHEMICAL LAND HOLDINGS, INC.

CSO TRIAL RUN SAMPLING (1/00)
SUMMARY OF WATER SAMPLE DATA

Analyte	Reporting Units	CSO0011CWFE-1 Filtered Water	DCSOCWFE-1 Filtered Water Dup.	CSO0011CWUE-1 Unfiltered Water	DCSOCWUE-1 Unfiltered Water Dup.	CSO00RB01 Rinse Blank	CSO00RB02 Rinse Blank
PCB Congeners (Continued)							
PCB-77	pg/L	1040 UJ	995 UJ	993 UJ	R	3330 UJ	3330 UJ
PCB-81	pg/L	1040 UJ	995 UJ	993 UJ	R	3330 UJ	3330 UJ
PCB-87	pg/L	1040 UJ	R	3980 J	3860 J	3330 UJ	4060 J
PCB-90/101	pg/L	2090 UJ	R	7510 J	7130 J	6670 UJ	6670 UJ
PCB-118	pg/L	1040 UJ	R	7550 J	6410 J	3330 UJ	3330 UJ
PCB-123	pg/L	1040 UJ	R	993 UJ	R	3330 UJ	3330 UJ
PCB-105	pg/L	1040 UJ	R	3440 J	2970 J	3330 UJ	3330 UJ
PCB-114	pg/L	1040 UJ	R	993 UJ	R	3330 UJ	3330 UJ
PCB-126	pg/L	1040 UJ	R	993 UJ	R	3330 UJ	3330 UJ
PCB-128	pg/L	1040 UJ	R	2570 J	1940 J	3330 UJ	3330 UJ
PCB-138	pg/L	1040 UJ	R	11700 J	10300 J	3330 UJ	3330 UJ
PCB-153	pg/L	1040 UJ	R	7240 J	7020 J	3330 UJ	3330 UJ
PCB-167	pg/L	1040 UJ	R	993 UJ	R	3330 UJ	3330 UJ
PCB-156	pg/L	1040 UJ	R	1400 J	1190 J	3330 UJ	3330 UJ
PCB-157	pg/L	1040 UJ	R	993 UJ	R	3330 UJ	3330 UJ
PCB-169	pg/L	1040 UJ	R	993 UJ	R	3330 UJ	3330 UJ
PCB-170	pg/L	1040 UJ	995 UJ	3200 J	3460 J	3330 UJ	3330 UJ
PCB-180	pg/L	1040 UJ	995 UJ	6800 J	6990 J	3330 UJ	3330 UJ
PCB-183	pg/L	1040 UJ	995 UJ	1430 J	1890 J	3330 UJ	3330 UJ
PCB-184	pg/L	1040 UJ	995 UJ	993 UJ	R	3330 UJ	3330 UJ
PCB-187	pg/L	1040 UJ	995 UJ	4110 J	4950 J	3330 UJ	3330 UJ
PCB-189	pg/L	1040 UJ	995 UJ	993 UJ	R	3330 UJ	3330 UJ
PCB-202	pg/L	1040 UJ	995 UJ	1940 J	1780 J	3330 UJ	3330 UJ
PCB-194	pg/L	1040 UJ	995 UJ	2660 J	2520 J	3330 UJ	3330 UJ
PCB-195	pg/L	1040 UJ	995 UJ	993 UJ	R	3330 UJ	3330 UJ
PCB-206	pg/L	1040 UJ	995 UJ	9680 J	8340 J	3330 UJ	3330 UJ
PCB-207	pg/L	1040 UJ	995 UJ	993 UJ	R	3330 UJ	3330 UJ
PCB-209	pg/L	1040 UJ	995 UJ	2650 J	2390 J	3330 UJ	8940 J

TABLE 3
CHEMICAL LAND HOLDINGS, INC.

CSO TRIAL RUN SAMPLING (1/00)
SUMMARY OF WATER SAMPLE DATA

Analyte	Reporting Units	CSO0011CWFE-1 Filtered Water	DCSOCWFE-1 Filtered Water Dup.	CSO0011CWUE-1 Unfiltered Water	DCSOCWUE-1 Unfiltered Water Dup.	CSO00RB01 Rinse Blank	CSO00RB02 Rinse Blank
Inorganics							
Aluminum	ug/L	83.2 B	75.2 B	1500 N	1150 N	84.9 BN	62.5 BN
Antimony	ug/L	3.4 U	3.4 U	3.4 U	3.4 U	3.4 U	3.4 U
Arsenic	ug/L	3.2 U	3.2 U	3.2 U	3.2 U	3.2 U	3.2 U
Barium	ug/L	12.9 BE	12.5 BE	63.6 B	50.1 B	0.85 B	3.9 B
Beryllium	ug/L	0.22 U	0.22 U	0.22 U	0.22 U	0.22 U	0.22 U
Cadmium	ug/L	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U
Calcium	ug/L	9780	9590	12100	11600	430 B	268 B
Chromium	ug/L	3.6 B	1.3 U	9.8 B	9.1 B	1.3 U	3.8 B
Cobalt	ug/L	1.6 U	1.6 U	1.6 U	1.6 U	1.6 U	1.6 U
Copper	ug/L	5.0 B	4.7 B	64.3 EJ	49.1 EJ	1.9 BE	1.8 BE
Iron	ug/L	87.5 B	61.6 B	2940 N	2170 N	63.2 BN	16.8 UN
Lead	ug/L	1.5 U	1.5 U	70.8	53.3	1.5 U	2.9 B
Magnesium	ug/L	1550 B	1530 B	2380 B	2190 B	22.6 U	22.6 U
Manganese	ug/L	31.8	32.0	89.2 EJ	71.4 EJ	1.2 BE	0.19 UE
Mercury	ug/L	0.041 U	0.041 U	0.061 B	0.049 B	0.041 U	0.041 U
Nickel	ug/L	1.2 U	1.2 U	6.8 B	4.8 B	1.2 U	1.2 U
Potassium	ug/L	1770 B	1750 B	2220 BNJH	2220 BNJH	22.3 UN	22.3 UN
Selenium	ug/L	2.2 U	2.2 U	2.2 UJL	2.2 UJL	2.2 UJL	2.2 UJL
Silver	ug/L	0.82 U	0.82 U	2.2 B	2.4 B	0.82 U	0.82 U
Sodium	ug/L	19600	19100	19100	20300	833 B	936 B
Thallium	ug/L	6.4 U	6.4 U	6.4 U	6.4 U	6.4 U	6.4 U
Vanadium	ug/L	1.2 B	1.4 B	5.6 B	5.0 B	0.87 U	0.87 U
Zinc	ug/L	R	R	R	R	109	5.0 B
Organotin							
Monobutyltin	ug Sn/L	0.0250 UJL	1.16 UJL	1.66 UJL	1.12 UJL	0.0250 UJL	0.574 JL
Dibutyltin	ug Sn/L	0.0250 UJL	0.0250 UJL	2.97 UJL	3.04 UJL	0.0250 UJL	0.136 JL
Tributyltin	ug Sn/L	1.45 UJL	1.52 UJL	2.78 UJL	1.47 UJL	1.21 GJL	1.18 GJL
Tetrabutyltin	ug Sn/L	0.0250 UJL	0.0250 UJL	0.0250 UJL	0.0250 UJL	0.0250 UJL	0.0250 UJL

TABLE 4
CHEMICAL LAND HOLDINGS, INC.

CSO TRIAL RUN SAMPLING (1/00)
SUMMARY OF UNUSED FILTER DATA

Analyte	Reporting Units	CSO0011CF Unused Filter
Semi-VOAs		
Phenol	ug/Kg	14000 U
bis(2-Chloroethyl)ether	ug/Kg	14000 U
2-Chlorophenol	ug/Kg	14000 U
1,3-Dichlorobenzene	ug/Kg	14000 U
1,4-Dichlorobenzene	ug/Kg	14000 U
1,2-Dichlorobenzene	ug/Kg	14000 U
2-Methylphenol	ug/Kg	14000 U
2,2'-oxybis(1-Chloropropane)	ug/Kg	14000 U
4-Methylphenol	ug/Kg	14000 U
N-Nitroso-di-n-propylamine	ug/Kg	14000 U
Hexachloroethane	ug/Kg	14000 U
Nitrobenzene	ug/Kg	14000 U
Isophorone	ug/Kg	14000 U
2-Nitrophenol	ug/Kg	14000 U
2,4-Dimethylphenol	ug/Kg	14000 U
bis(2-Chloroethoxy)methane	ug/Kg	14000 U
2,4-Dichlorophenol	ug/Kg	14000 U
1,2,4-Trichlorobenzene	ug/Kg	14000 U
Naphthalene	ug/Kg	14000 U
4-Chloroaniline	ug/Kg	14000 U
Hexachlorobutadiene	ug/Kg	14000 U
4-Chloro-3-methylphenol	ug/Kg	14000 U
2-Methylnaphthalene	ug/Kg	14000 U
Hexachlorocyclopentadiene	ug/Kg	27000 U
2,4,6-Trichlorophenol	ug/Kg	14000 U
2,4,5-Trichlorophenol	ug/Kg	14000 U
2-Chloronaphthalene	ug/Kg	14000 U
2-Nitroaniline	ug/Kg	14000 U
Dimethylphthalate	ug/Kg	14000 U
Acenaphthylene	ug/Kg	14000 U
3-Nitroaniline	ug/Kg	14000 U
Acenaphthene	ug/Kg	14000 U
2,4-Dinitrophenol	ug/Kg	82000 U
4-Nitrophenol	ug/Kg	34000 U
Dibenzofuran	ug/Kg	14000 U
2,4-Dinitrotoluene	ug/Kg	14000 U
2,6-Dinitrotoluene	ug/Kg	14000 U
Diethylphthalate	ug/Kg	14000 U
4-Chlorophenyl-phenylether	ug/Kg	14000 U
Fluorene	ug/Kg	14000 U

(See Data Qualifier Sheet for explanation of data qualifiers)

TABLE 4
CHEMICAL LAND HOLDINGS, INC.

CSO TRIAL RUN SAMPLING (1/00)
SUMMARY OF UNUSED FILTER DATA

Analyte	Reporting Units	CSO0011CF Unused Filter
Semi-VOAs (Continued)		
4-Nitroaniline	ug/Kg	14000 U
4,6-Dinitro-2-methylphenol	ug/Kg	34000 U
N-Nitrosodiphenylamine	ug/Kg	14000 U
4-Bromophenyl-phenylether	ug/Kg	14000 U
Hexachlorobenzene	ug/Kg	14000 U
Pentachlorophenol	ug/Kg	34000 U
Phenanthrene	ug/Kg	14000 U
Anthracene	ug/Kg	14000 U
Carbazole	ug/Kg	14000 U
Di-n-butylphthalate	ug/Kg	14000 U
Fluoranthene	ug/Kg	14000 U
Pyrene	ug/Kg	14000 U
Butylbenzylphthalate	ug/Kg	14000 U
3,3'-Dichlorobenzidine	ug/Kg	27000 U
Benzo(a)anthracene	ug/Kg	14000 U
bis(2-Ethylhexyl)phthalate	ug/Kg	14000 U
Chrysene	ug/Kg	14000 U
Di-n-octylphthalate	ug/Kg	14000 U
Benzo(b)fluoranthene	ug/Kg	14000 U
Benzo(k)fluoranthene	ug/Kg	14000 U
Benzo(a)pyrene	ug/Kg	14000 U
Indeno(1,2,3-cd)pyrene	ug/Kg	14000 U
Dibenz(a,h)anthracene	ug/Kg	14000 U
Benzo(g,h,i)perylene	ug/Kg	14000 U
Pesticides/PCB Aroclors		
Alpha BHC	ug/Kg	13 G
Beta BHC	ug/Kg	14 U
Delta BHC	ug/Kg	14 U
Gamma BHC - Lindane	ug/Kg	14 U
Heptachlor	ug/Kg	14 U
Aldrin	ug/Kg	14 U
Heptachlor Epoxide	ug/Kg	14 U
Endosulfan I	ug/Kg	14 U
Dieldrin	ug/Kg	28 U
DDE	ug/Kg	28 U
Endrin	ug/Kg	28 UJ
Endosulfan II	ug/Kg	28 U
DDD	ug/Kg	28 UJ
Endosulfan Sulfate	ug/Kg	28 UJ

(See Data Qualifier Sheet for explanation of data qualifiers)

TABLE 4
CHEMICAL LAND HOLDINGS, INC.

CSO TRIAL RUN SAMPLING (1/00)
SUMMARY OF UNUSED FILTER DATA

Analyte	Reporting Units	CSO0011CF Unused Filter
Pesticides/PCB Aroclors (Continued)		
DDT	ug/Kg	28 UJ
Endrin Ketone	ug/Kg	28 UJ
Methoxychlor	ug/Kg	140 UJ
Alpha Chlordane	ug/Kg	14 U
Gamma Chlordane	ug/Kg	14 UJ
Toxaphene	ug/Kg	1400 U
Endrin Aldehyde	ug/Kg	28 U
PCB-1016	ug/Kg	710 U
PCB-1221	ug/Kg	710 U
PCB-1232	ug/Kg	710 U
PCB-1242	ug/Kg	710 U
PCB-1248	ug/Kg	710 U
PCB-1254	ug/Kg	710 U
PCB-1260	ug/Kg	710 U
Herbicides		
2,4-D	ug/Kg	710 U
2,4,5-TP (Silvex)	ug/Kg	100 U
2,4,5-T	ug/Kg	100 U
2,4-DB	ug/Kg	R
Dioxin/Furan		
2,3,7,8-TCDD	pg/Sample	2.57 UJ
1,2,3,7,8-PeCDD	pg/Sample	3.42 UJ
1,2,3,4,7,8-HxCDD	pg/Sample	3.64 UJ
1,2,3,6,7,8-HxCDD	pg/Sample	4.03 UJ
1,2,3,7,8,9-HxCDD	pg/Sample	3.57 UJ
1,2,3,4,6,7,8-HpCDD	pg/Sample	7.27 UJ
OCDD	pg/Sample	89.1 J
2,3,7,8-TCDF	pg/Sample	1.40 UJ
1,2,3,7,8-PeCDF	pg/Sample	4.58 UJ
2,3,4,7,8-PeCDF	pg/Sample	3.65 UJ
1,2,3,4,7,8-HxCDF	pg/Sample	1.82 UJ
1,2,3,6,7,8-HxCDF	pg/Sample	1.77 UJ
2,3,4,6,7,8-HxCDF	pg/Sample	1.36 UJ
1,2,3,7,8,9-HxCDF	pg/Sample	2.56 UJ
1,2,3,4,6,7,8-HpCDF	pg/Sample	6.16 UJ
1,2,3,4,7,8,9-HpCDF	pg/Sample	6.14 UJ
OCDF	pg/Sample	25.0 U

(See Data Qualifier Sheet for explanation of data qualifiers)

TABLE 4
CHEMICAL LAND HOLDINGS, INC.

CSO TRIAL RUN SAMPLING (1/00)
SUMMARY OF UNUSED FILTER DATA

Analyte	Reporting Units	CSO0011CF Unused Filter
PCB Congeners		
PCB-1	ng/Sample	1000 U
PCB-3	ng/Sample	1000 U
PCB-8	ng/Sample	10000 U
PCB-15	ng/Sample	10000 U
PCB-18	ng/Sample	R
PCB-28	ng/Sample	R
PCB-44	ng/Sample	1000 UJ
PCB-52	ng/Sample	1000 UJ
PCB-66	ng/Sample	1000 UJ
PCB-77	ng/Sample	1000 UJ
PCB-81	ng/Sample	1000 UJ
PCB-87	ng/Sample	1000 U
PCB-90/101	ng/Sample	2000 U
PCB-118	ng/Sample	1000 U
PCB-123	ng/Sample	1000 U
PCB-105	ng/Sample	1000 U
PCB-114	ng/Sample	1000 U
PCB-126	ng/Sample	1000 U
PCB-128	ng/Sample	1000 U
PCB-138	ng/Sample	1000 U
PCB-153	ng/Sample	1000 U
PCB-167	ng/Sample	1000 U
PCB-156	ng/Sample	1000 U
PCB-157	ng/Sample	1000 U
PCB-169	ng/Sample	1000 U
PCB-170	ng/Sample	1000 UJ
PCB-180	ng/Sample	1000 UJ
PCB-183	ng/Sample	1000 UJ
PCB-184	ng/Sample	1000 UJ
PCB-187	ng/Sample	1000 UJ
PCB-189	ng/Sample	1000 UJ
PCB-202	ng/Sample	1000 UJ
PCB-194	ng/Sample	1000 UJ
PCB-195	ng/Sample	1000 UJ
PCB-206	ng/Sample	1000 UJ
PCB-207	ng/Sample	1000 UJ
PCB-209	ng/Sample	1000 UJ

(See Data Qualifier Sheet for explanation of data qualifiers)

TABLE 4
CHEMICAL LAND HOLDINGS, INC.

CSO TRIAL RUN SAMPLING (1/00)
SUMMARY OF UNUSED FILTER DATA

Analyte	Reporting Units	CSO0011CF Unused Filter
Inorganics		
Aluminum	mg/Kg	13800 *
Antimony	mg/Kg	0.21 U
Arsenic	mg/Kg	0.49 U
Barium	mg/Kg	22600 *
Beryllium	mg/Kg	0.13 B
Cadmium	mg/Kg	0.12 B
Calcium	mg/Kg	6590
Chromium	mg/Kg	10.5
Cobalt	mg/Kg	3.9 B
Copper	mg/Kg	0.48 B*NJH
Iron	mg/Kg	181 *
Lead	mg/Kg	2.4 *
Magnesium	mg/Kg	653 B
Manganese	mg/Kg	6.0 *
Mercury	mg/Kg	0.0045 B
Nickel	mg/Kg	0.73 B
Potassium	mg/Kg	14100
Selenium	mg/Kg	0.38 U
Silver	mg/Kg	0.14 B
Sodium	mg/Kg	38300 *
Thallium	mg/Kg	0.88 B
Vanadium	mg/Kg	0.31 B
Zinc	mg/Kg	17200 *
Organotin		
Monobutyltin	ug Sn/Kg	1.00 UJL
Dibutyltin	ug Sn/Kg	8.67 JL
Tributyltin	ug Sn/Kg	31.7 JL
Tetrabutyltin	ug Sn/Kg	1.00 UJL

(See Data Qualifier Sheet for explanation of data qualifiers)

**CSO TRIAL RUN SAMPLING (1/00)
DATA QUALIFIER SHEET**

QUALIFIER	DESCRIPTION
B	The reported value was obtained from an instrument reading that was less than the sample quantitation limit (SQL).
E	The reported value is estimated because of the presence of an interference.
G	Organic data indicated the presence of a compound that meets the identification criteria; the result is below the SQL but above the MDL.
N	Matrix spike sample recovery is not within control limits.
U	The analyte was analyzed for, but was not detected above the reported sample quantitation limit.
*	The laboratory duplicate analysis is not within control limits.
J	Estimated value - The analyte was positively identified; but the associated numerical value is the approximate concentration of the analyte in the sample.
NJ	The analysis indicates the presence of an analyte that has been "tentatively identified" and the associated numerical value represents its approximate concentration.
UJ	The analyte was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit necessary to accurately and precisely measure the analyte in the sample.
R	The sample results are rejected. Due to significant QA/QC problem the analysis is invalid and provides no information as to whether the analyte is present or not.
JL	If the data reviewer can determine the overall bias for sample data qualified as estimated, the reviewer will qualify the sample result as estimated minimum value (JL).
JH	If the data reviewer can determine the overall bias for sample data qualified as estimated, the reviewer will qualify the sample result as estimated maximum value (JH).
M	The analytical result reported was obtained from a sediment sample found to contain between 50 and 90 percent moisture and had no other data qualifiers added during the data validation process.

TABLE 5
CSO INFORMATION SUMMARY

ESP OUTFALL NUMBER	CSO NJPDES PERMIT No.	LOCATION OR STREET NAME	BULK SAMPLING FEASIBLE?	SEDIMENT TRAP FEASIBLE	TIDE INTRUSION LIKELY? (Based on elev.)	ELEV. BEHIND STOPLOG (DATUM ELEV. 100 FT)	ELEV. BOTTOM OF TG CHAMBER (DATUM ELEV. 100 FT)	Est. HIGH TIDE ELEV BASED ON SAYBROOK TRIAL (DATUM ELEV. 100 FT)	OVERFLOW FREQUENCY (times/yr)*	EST MAX. DISCHARGE TO RIVER (mld)*
1	- ?	Roanoke Avenue	NOT INSPECTED	NOT INSPECTED	?	?	?	102.5	?	?
2	026/K-010	Duke Street	YES - Limited traffic control required. Located in residential neighborhood.	YES - Sediment Traps feasible although TG chamber installation may be preferable. Limited space behind SL would limit number of traps. Traps would be packed in tight.	YES	101.2	101.18	102.5	65-80	24.6
3	025/K-009	Tappan Street	YES - Limited traffic control required. Located in residential neighborhood.	YES - Sediment trap installation feasible although difficult due to shallow MH. Tide gate chamber more floor room but small entry.	POSSIBLE	103.3	103.3	102.5	45-55	32.93
4	024/K-008	Bergen Avenue (East)	NOT OPERATIONAL	NOT OPERATIONAL	INACTIVE	INACTIVE	INACTIVE	102.5	INACTIVE	INACTIVE
5	023/K-007	Ivy Street	YES - MH in alley used for parking by residents. Residential area. Access down MH blocked by planks.	YES - Sediment traps feasible if can access MH. Access down MH blocked by planks.	YES	101.2	NO ELEVATION ON DRAWING	102.5	50-65	923.54
6	016/H-007	Worthington Avenue	YES - Traffic control required.	MARGINAL - Sediment trap installation likely infeasible in SC due to limited space. TG chamber installation feasible but spacing limited by TG clearance.	YES	101.8	101.6	102.5	NO OVERFLOW	30.47
7	041/N-014	Freeman Street	LIKELY - Traffic control required. Parking space will need to be addressed.	MARGINAL - Sediment Trap installation infeasible due to limited accessibility from MH to area behind SL. Scaffold or work bridge required to access area. Installation in TG chamber may be feasible if not covered by intermodal containers. TG chamber has plate instead of MH.	YES	99.36	99.2	102.5	5**	60.56
8	040/N-013	Polk Street	LIKELY - Traffic control required. Parking space will need to be addressed.	YES - Sediment Trap installation feasible. Large area between SL and TG for installation on floor of SC. Depth of MH and traffic considerations.	YES	96.6	96.27	102.5	45-60	234.67
9	039/N-012	Jackson Street	LIKELY - Bulk sampling would require closure of Jackson SL. Relatively tight traffic so may be feasible. Close to Raymond Blvd.	YES - Sediment trap installation feasible in area behind SL.	YES	97.37	96.7	102.5	Low**	253.6
10	038/N-011	City Dock	LIKELY - Traffic control required. Parking space will need to be addressed.	YES - Sediment Trap installation feasible in SC and TG chambers.	YES	96.67	96.17	102.5	45-55	420.14
11	037/N-010	Saybrook Place	YES - Good access and off-street parking.	YES - Sediment Trap installation feasible.	YES	101.22	100.64	102.5	35-45	336.87
12	014/H-005	Middlesex Street	YES - Traffic control required.	YES - Sediment trap installation appears feasible in area behind SL. However, installation difficult due to MH configuration. TG chamber installation may be easier.	YES	99.6	99.5	102.5	50-60	47.69
13	036/N-009	Rector Street	YES - Good access and parking.	YES - Sediment Trap installation feasible in SC and TG chambers. TG chamber has plate covers instead of MH cover.	POSSIBLE	103.2	102.8	102.5	31	257.38
14	015/H-006	Bergen Street	YES - Traffic control required.	YES - Insufficient space behind SL for installation. TG chamber installation appears feasible.	YES	98.9	98.7	102.5	60-75	9.08

TABLE 5
CSO INFORMATION SUMMARY

ESP OUTFALL NUMBER	CSO NJPDES PERMIT No.	LOCATION OR STREET NAME	BULK SAMPLING FEASIBLE?	SEDIMENT TRAP FEASIBLE	TIDE INTRUSION LIKELY? (Based on elev.)	ELEV. BEHIND STOPLOG (DATUM ELEV. 100 FT)	ELEV. BOTTOM OF TG CHAMBER (DATUM ELEV. 100 FT)	Est. HIGH TIDE ELEV BASED ON SAYBROOK TRIAL (DATUM ELEV. 100 FT)	OVERFLOW FREQUENCY (times/yr)*	EST MAX. DISCHARGE TO RIVER (mld)*
15	013/H-004	Dey Street	YES - Traffic control required.	YES - Sediment trap installation feasible in area behind SL. However very close spacing of traps required and may need to install fewer traps. TG chamber installation may be easier.	YES	101.3	101.1	102.5	40-55	30.28
16	012/H-003	Harrison Avenue	LIKELY - Traffic control required on approach to bridge.	YES - Installation in TG chamber recommended due to limited space in SC. Small entry to TG chamber will need to be considered for installation.	YES	102.66	102.2	102.5	45-55	75.7
17	035/N-008	Bridge Street	LIKELY - Traffic control required. Parking space will need to be addressed.	MARGINAL - Sediment trap installation infeasible due to limited space; may be able to install fewer sediment traps.	NO	108.12	NO TIDE GATE	102.5	NO OVERFLOW	NONE
18	011/H-002	Cleveland Avenue	LIKELY - Traffic control required. Parking space will need to be addressed.	YES - Installation in TG chamber recommended due to limited space in SC. Small entry to TG chamber will need to be considered for installation.	YES	101.67	101.4	102.5	40-50	46.18
19	034/N-007	Orange Street	LIKELY - Traffic control required.	YES - Sediment trap approach appears feasible based on PVSC drawing. Small area behind SL may require fewer sediment traps or tighter cluster.	NO	105.17	NO TIDE GATE	102.5	NO OVERFLOW	NONE
20	010/H-001	New Street	LIKELY - Traffic control required. Parking space will need to be addressed.	YES - Installation in TG chamber recommended due to limited space in SC. Small entry to TG chamber will need to be considered for installation.	YES	100.72	100.74	102.5	55-70	68.13
21	033/N-006	Clay Street	LIKELY - Traffic control required.	MARGINAL - Sediment trap sampling appears feasible based on PVSC drawings. Traffic control a required. (Could not inspect TG/diversion chamber due to traffic.)	YES	101.91	NO DRAWING AVAILABLE FOR TIDE GATE CHAMBER	102.5	APPROX. 56	1275.55
22	008/E-001	Central Avenue	LIKELY - Traffic control required. Parking space will need to be addressed.	YES - Installation in TG chamber recommended due to limited space in SC. Small entry to TG chamber will need to be considered for installation.	YES	100.41	100.16	102.5	50-65	233.16
23	022/K-006	Johnston Avenue	LIKELY - MH location in parking area for car dealer. May be feasible during daylight hours or with adequate coordination with car dealer.	YES - Sediment Trap approach feasible in SC.	YES	99.7	99.7	102.5	50-65	423.92
24	032/N-005	Fourth Avenue	LIKELY - MH location in gated parking area. May be feasible during daylight hours or with cooperation from property owner.	YES - Sediment trap installation feasible.	YES	102.3	101.7	102.5	55-70	234.67 (INCL. 3RD AVE.)
25	021/K-005	Marshall Street	LIKELY - Traffic control required; police control likely necessary.	YES - Sediment trap approach infeasible in SC cannot reach area behind SL. Installation feasible in TG chamber.	YES	100.1	100.1	102.5	30-40	18.93
26	031/N-004	Third Avenue	LIKELY - MH location in gated parking area. May be feasible during daylight hours or with cooperation from property owner.	YES - Sediment trap installation feasible, but narrow area would make installation tight. TG chamber would allow easier installation.	YES	102.28	102.18	102.5	NO OVERFLOW	INCLUDED IN 4TH AVE.

82697134

TABLE 5

CSO INFORMATION SUMMARY

ESP OUTFALL NUMBER	CSO NJPDES PERMIT No.	LOCATION OR STREET NAME	BULK SAMPLING FEASIBLE?	SEDIMENT TRAP FEASIBLE	TIDE INTRUSION LIKELY? (Based on elev.)	ELEV. BEHIND STOPLOG (DATUM ELEV. 100 FT)	ELEV. BOTTOM OF TG CHAMBER (DATUM ELEV. 100 FT)	Est. HIGH TIDE ELEV BASED ON SAYBROOK TRIAL (DATUM ELEV. 100 FT)	OVERFLOW FREQUENCY (times/yr)*	EST MAX. DISCHARGE TO RIVER (mld)*
27	020/K-004	Naim St	LIKELY - Traffic control required; police control likely necessary.	YES - Sediment trap approach feasible in outfall MH. Configuration of MH bottom will require consideration prior to installation.	NO	NA	NO TIDEGATE	102.5	?	9.84
28	019/K-003	Bergen Avenue (West)	NOT OPERATIONAL	NOT OPERATIONAL	INACTIVE	INACTIVE	INACTIVE	102.5	INACTIVE	INACTIVE
29	030/N-003	Herbert Place	YES - Water quality monitoring must be performed with permanent installation.	YES - Sediment Trap installation feasible. MARGINAL - Insufficient space behind SL for installation. TG chamber installation may be possible, but unlikely based on general configuration. Additional drawings of chambers required from PVSC.	NO	104.95	NO TIDEGATE	102.5	31**	416.35
-	?	Passaic Street	LIKELY - Traffic control required. MH in center of street close to busy intersection.		NO DRAWING AVAILABLE	NO DRAWING AVAILABLE	NO DRAWING AVAILABLE	102.5	?	?

Notes:

*Based on the assumption that rainfalls will occur from 70-90 times per year.

**Period of observation was one in which rainfall was relatively low (see files for rainfall occurrences)

DC = Diversion Chamber

SC = Sandcatcher Chamber

RC = Regulator Chamber

Regulator Chamber Valve: Inactive = automatic valve disabled valve open or partially open; Active = automatic valve functional; Removed = valve removed; Sluice=Electric Operated Sluice w/Local and Plant Control

TC = Tidegate Chamber

SIC = Siphon Inlet Chamber

SOC = Siphon Outlet Chamber

SOM = Siphon Outlet Manhole

FG = Flap Gate

GR = Gates Removed

VTP = Vitrified Tile Pipe

mld = Million Liters/Day

NR = Not Readable

82697135

ATTACHMENT 1

PARTICLE SIZE ANALYSIS RESULTS

82697136

Particle Technology Labs, Ltd.

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FDA Certificate# 1422692



March 9, 2000

BLASLAND, BOUCK, & LEE
6723 Towpath Road
P.O. Box 66
Syracuse, NY 13214

Attn: Mr. Russell Houck
cc: Mr. Cliff Firstenberg

Subject: Malvern and Sieve Particle Size Analyses of One Combined Filter Sample and One Soil/Sediment Sample

PTL Projects: 4159

Dear Mr. Houck:

Enclosed are the results from the Malvern and sieve particle size analyses performed on your one Combined Filter sample and one Soil/Sediment sample received 3/3/00. The particle size of the Combined Filters was determined on our Malvern Mastersizer S LASER diffractor. As requested, one filter from each of the four jars was selected at random. Each filter was wetted with sodium pyrophosphate and Triton X-100 in water. The particulate from each filter was then removed, combined into a large beaker and ultrasonicated for a timed one minute. The sample was then analyzed according to standard operating procedures for this instrumentation type.

As discussed, the Soil/Sediment sample contained particulate larger in size than the upper detection limit of the instrument (900 microns). Therefore it was necessary to first perform a sieve analysis in order to capture the percent of particulate larger than 850 microns. An aliquot portion of the sample was dispersed with sodium pyrophosphate and Triton X-100 in water, ultrasonicated for a timed one minute, and then sieved through a standard size 850-micron sieve. The material greater than 850 microns was dried and the percent of particulate greater than 850 microns was calculated. The material less than 850 microns was placed in the Malvern's recirculating bath of water and analyzed according to standard operating procedures for our Malvern Mastersizer S LASER diffractor. The results from both techniques were then normalized and blended into one complete distribution; see Table 1.

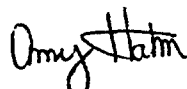
The samples were very floccy in nature, creating instability in the analysis over the first four-minute period. Due to instability, we then instructed the instrument to perform additional analyses

until stability over time (reproducible results) was achieved. Therefore, two analysis have been submitted for your review; the first initial analysis and an analysis which reflects one of the stable readings.

Please note that the data from the Soil/Sediment sample has been normalized for both the initial and stable analysis.

If you have any questions regarding this data or the methods used to acquire the data, please do not hesitate to contact us here at Particle Technology Labs.

Submitted by,



Amy Hahn

Reviewed by,



Kelli Hubert

TABLE 1

BLENDED SIEVE AND MALVERN DATA

SAMPLE ID	SIZE μm	CUMULATIVE WT% < INDICATED SIZE
Soil/Sediment "Initial Run"	Sieve Data	850
		98.4
	Malvern	722.7
	Data	97.9
		655.4
		97.2
		539.0
		94.9
		443.3
		91.4
		364.6
		86.7
		271.9
		78.1
		166.8
		62.8
		102.3
		49.9
		84.2
		45.31
		46.8
		33.2
		17.6
		18.1
		7.31
		9.6
		1.03
		2.3
		0.4
		1.3

SAMPLE ID	SIZE μm	CUMULATIVE WT% < INDICATED SIZE
Soil/Sediment "Stable Run"	Sieve Data	850
		98.4
	Malvern	722.7
	Data	98.4
		655.4
		97.4
		539.0
		95.2
		443.3
		91.6
		364.6
		84.7
		271.9
		72.1
		166.8
		60.3
		102.3
		55.9
		84.2
		42.0
		46.8
		24.0
		17.6
		13.2
		7.31
		3.1
		1.03
		1.7
		0.4
		1.3

Particle Technology Labs, Ltd.



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FDA Certificate # 1422692

INTERPRETING YOUR MALVERN FINE PARTICLE ANALYSIS

INTRODUCTION

Your samples have been analyzed on a Malvern MasterSizer S LASER particle size analyzer. This instrument analyzes particles on an ensemble basis, calculating a volume distribution from the LASER diffraction pattern of particle diameters.

THE REPORT

The information presented in your report consists of four basic categories:

SAMPLE DETAILS: The first section of the report page consists of **SAMPLE DETAILS:** client, sample identification, and sample conditioning information. If you find it necessary to contact us concerning this work, please refer to the four-digit PTL Project #, which appears under *Sample File*.

SYSTEM DETAILS: This section describes parameters specific to the instrument being used as well as to the analysis. It should be noted that in the size region of 0.1 - 3 microns, LASER technology is sensitive to the refractive index (RI) of the sample material. Therefore, a standard instrument default value for the refractive index of the sample and carrier fluid is normally used if one is not provided by the client. A sample RI value of 1.5295 (glass beads) is used along with a carrier fluid RI of 1.33 (water). Likewise, the **Presentation: OHD** and **Analysis Model: Polydisperse** is used as a default. For samples analyzed on a **dry** basis, the particle RI is 1.45 with a dispersant RI of 1.00 (air). Correspondingly, the **Presentation: RHA** is used as the default. If the client provides a RI at a later date, the raw data can be recalculated to adjust for the refractive index.

RESULT STATISTICS: This section presents

1. Statistics
 - A. ***Statistics ALWAYS appear as "Percent Less Than" or "% Under."***
 - B. Span is defined as the 90% - 10% size divided by the 50% size level.
 - C. The Surface to Volume mean diameter is reported as the D[3,2] value.
 - D. The Mean Volume statistic is reported as the D[4,3] value.
 - E. The 90%, 50%, and the 10% size values appear as D[v,0.90], D[v,0.50] and D[v,0.10] respectively.
 - F. A calculated Specific Surface Area value is reported. However, consider this value only as an approximate surface area since calculations are based upon smooth spheres.
2. Tabulated data as a Cumulative Weight Percent Greater Than (Or Less Than) Indicated Size.

HISTOGRAM: This last section displays the differential histogram as well as the cumulative curve for the data displayed in the table above.

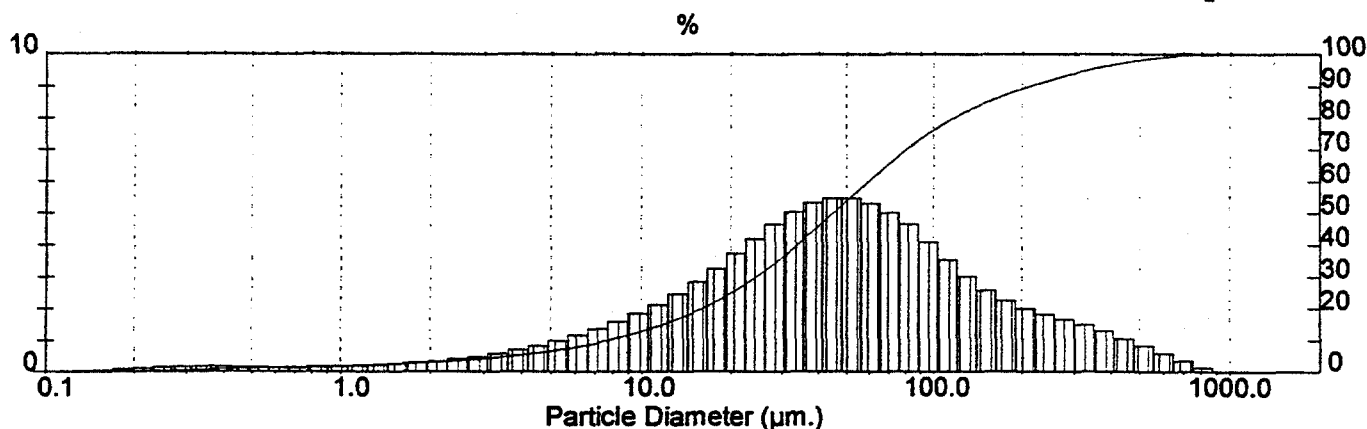
Result: Histogram Report

Sample Details		
Sample ID: CS00011SDFS03	Run Number: 5	Measured: Tue Mar 7 2000 5:49PM
Sample File: 4159	Record Number: 5	Analysed: Tue Mar 7 2000 5:49PM
Sample Path: A:\		Result Source: Analysed
Sample Notes: BLASLAND, BOUCK & LEE Combined Filters		
Carrier: Water Dispersant: Triton X-100. Na Pyrophos		
Ultrasonic: 1 minute Tech: AH		
Particle Technology Labs PTL: 23406,23407,23408,23409		

System Details		
Range Lens: 300RF mm	Beam Length: 2.40 mm	Sampler: MS17
Presentation: 3OHD	[Particle R.I. = (1.5295, 0.1000);	Dispersant R.I. = 1.3300]
Analysis Model: Polydisperse		Obscuration: 13.4 %
Modifications: None		Residual: 0.453 %

Result Statistics			
Distribution Type: Volume	Concentration = 0.0279 %Vol	Density = 1.000 g / cub. cm	Specific S.A. = 0.6914 sq. m / g
Mean Diameters:	D (v, 0.1) = 7.65 um	D (v, 0.5) = 44.82 um	D (v, 0.9) = 211.00 um
D [4, 3] = 84.29 um	D [3, 2] = 8.68 um	Span = 4.537E+00	Uniformity = 1.419E+00

Size (um)	Volume Under %	Size (um)	Volume Under %	Size (um)	Volume Under %	Size (um)	Volume Under %
0.055	0.00	0.635	1.59	7.31	9.57	84.15	71.52
0.061	0.00	0.700	1.69	8.06	10.51	92.79	74.35
0.067	0.00	0.772	1.79	8.89	11.54	102.3	76.93
0.074	0.01	0.851	1.89	9.80	12.67	112.8	79.29
0.082	0.01	0.938	2.00	10.81	13.91	124.4	81.42
0.090	0.02	1.03	2.11	11.91	15.28	137.2	83.35
0.099	0.03	1.14	2.24	13.14	16.78	151.3	85.10
0.109	0.05	1.26	2.38	14.49	18.42	166.8	86.68
0.121	0.07	1.39	2.52	15.97	20.23	183.9	88.14
0.133	0.09	1.53	2.68	17.62	22.21	202.8	89.48
0.147	0.13	1.69	2.86	19.42	24.36	223.6	90.74
0.162	0.17	1.86	3.05	21.42	26.71	246.6	91.92
0.178	0.23	2.05	3.27	23.62	29.25	271.9	93.04
0.196	0.30	2.26	3.50	26.04	31.98	299.8	94.09
0.217	0.38	2.49	3.76	28.72	34.90	330.6	95.07
0.239	0.48	2.75	4.05	31.66	37.99	364.6	95.98
0.263	0.58	3.03	4.37	34.92	41.23	402.0	96.81
0.290	0.69	3.34	4.73	38.50	44.60	443.3	97.54
0.320	0.81	3.69	5.13	42.45	48.06	488.8	98.18
0.353	0.93	4.07	5.58	46.81	51.57	539.0	98.72
0.389	1.05	4.48	6.08	51.62	55.09	594.3	99.16
0.429	1.17	4.94	6.64	56.92	58.58	655.4	99.52
0.473	1.28	5.45	7.26	62.76	62.00	722.7	99.78
0.522	1.39	6.01	7.96	69.21	65.30	796.9	99.91
0.576	1.49	6.63	8.72	76.32	68.48	878.7	100.00



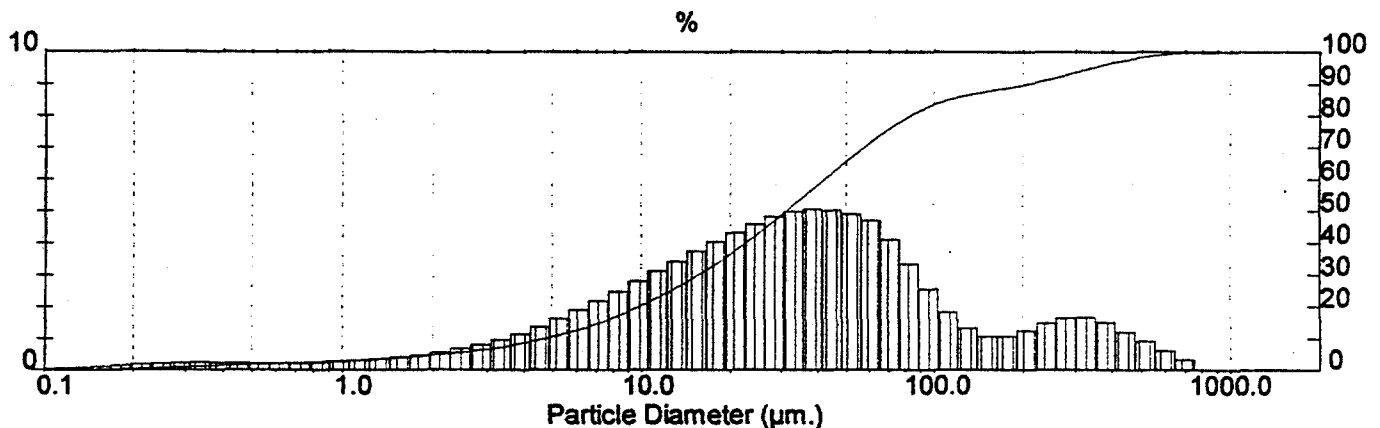
Result: Histogram Report

Sample Details		
Sample ID: CS00011SDFS03	Run Number: 16	Measured: Tue Mar 7 2000 6:02PM
Sample File: 4159	Record Number: 16	Analysed: Tue Mar 7 2000 6:02PM
Sample Path: A:\		Result Source: Analysed
Sample Notes: BLASLAND, BOUCK & LEE Combined Filters		
Carrier: Water Dispersant: Triton X-100. Na Pyrophos		
Ultrasonic: 1 minute Tech: AH		
Particle Technology Labs PTL: 23406,23407,23408,23409		

System Details		
Range Lens: 300RF mm	Beam Length: 2.40 mm	Sampler: MS17
Presentation: 30HD	[Particle R.I. = (1.5295, 0.1000);	Dispersant R.I. = 1.3300]
Analysis Model: Polydisperse		Obscuration: 12.5 %
Modifications: None		Residual: 0.475 %

Result Statistics			
Distribution Type: Volume	Concentration = 0.0183 %Vol	Density = 1.000 g / cub. cm	Specific S.A. = 1.0225 sq. m / g
Mean Diameters:	D (v, 0.1) = 4.70 um	D (v, 0.5) = 31.07 um	D (v, 0.9) = 207.50 um
D [4, 3] = 71.28 um	D [3, 2] = 5.87 um	Span = 6.528E+00	Uniformity = 1.862E+00

Size (um)	Volume Under %	Size (um)	Volume Under %	Size (um)	Volume Under %	Size (um)	Volume Under %
0.055	0.00	0.635	2.36	7.31	15.26	84.15	80.40
0.061	0.00	0.700	2.50	8.06	16.75	92.79	82.30
0.067	0.01	0.772	2.65	8.89	18.37	102.3	83.88
0.074	0.02	0.851	2.80	9.80	20.11	112.8	85.16
0.082	0.03	0.938	2.97	10.81	21.98	124.4	86.19
0.090	0.05	1.03	3.15	11.91	23.98	137.2	87.02
0.099	0.07	1.14	3.35	13.14	26.11	151.3	87.73
0.109	0.10	1.26	3.56	14.49	28.36	166.8	88.40
0.121	0.14	1.39	3.80	15.97	30.74	183.9	89.07
0.133	0.18	1.53	4.05	17.62	33.25	202.8	89.81
0.147	0.25	1.69	4.34	19.42	35.87	223.6	90.64
0.162	0.32	1.86	4.65	21.42	38.62	246.6	91.57
0.178	0.41	2.05	4.99	23.62	41.47	271.9	92.59
0.196	0.52	2.26	5.36	26.04	44.43	299.8	93.65
0.217	0.64	2.49	5.78	28.72	47.48	330.6	94.73
0.239	0.78	2.75	6.25	31.66	50.61	364.6	95.77
0.263	0.93	3.03	6.77	34.92	53.81	402.0	96.72
0.290	1.09	3.34	7.36	38.50	57.03	443.3	97.56
0.320	1.26	3.69	8.02	42.45	60.27	488.8	98.27
0.353	1.43	4.07	8.75	46.81	63.49	539.0	98.87
0.389	1.59	4.48	9.58	51.62	66.65	594.3	99.34
0.429	1.75	4.94	10.50	56.92	69.76	655.4	99.70
0.473	1.91	5.45	11.52	62.76	72.80	722.7	99.96
0.522	2.06	6.01	12.65	69.21	75.63	796.9	100.00
0.576	2.21	6.63	13.90	76.32	78.17	878.7	100.00



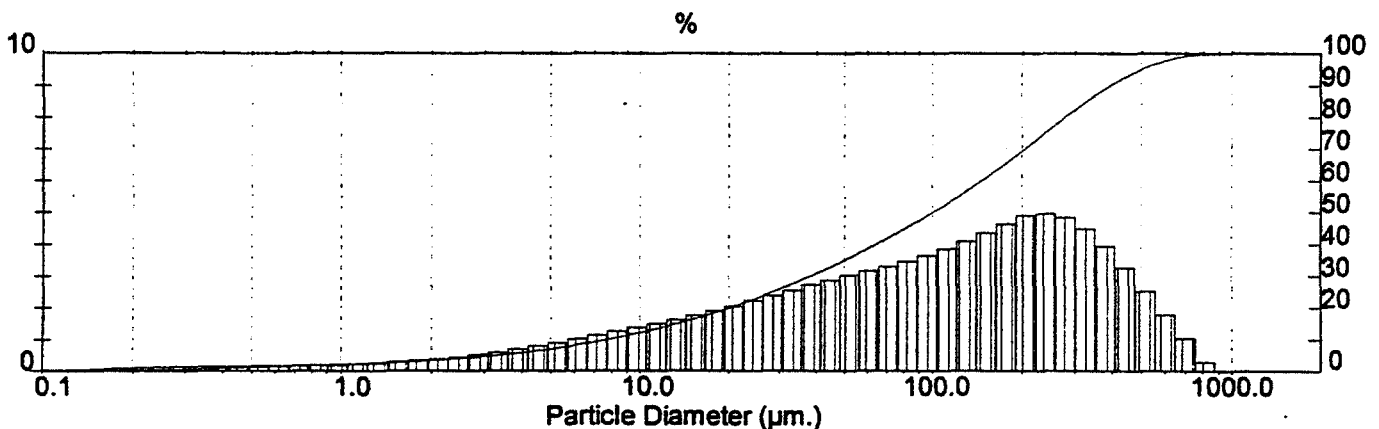
Result: Histogram Report

Sample Details		
Sample ID: CS00011SD5502	Run Number: 1	Measured: Wed Mar 8 2000 10:37AM
Sample File: 4159	Record Number: 17	Analysed: Wed Mar 8 2000 10:38AM
Sample Path: A:\		Result Source: Analysed
Sample Notes: BLASLAND, BOUCK & LEE Soil/ Sediment		
Carrier: Water Dispersant: Triton X-100. Na Pyrophos		
Ultrasonic: 1 minute Tech: AH		
Particle Technology Labs PTL: 23410		

System Details		
Range Lens: 300RF mm	Beam Length: 2.40 mm	Sampler: MS17
Presentation: 3OHD	[Particle R.I. = (1.5295, 0.1000);	Dispersant R.I. = 1.3300]
Analysis Model: Polydisperse		Obscuration: 25.7 %
Modifications: None		Residual: 0.414 %

Result Statistics			
Distribution Type: Volume	Concentration = 0.0625 %Vol	Density = 1.000 g / cub. cm	Specific S.A. = 0.7328 sq. m / g
Mean Diameters:	D (v, 0.1) = 7.60 um	D (v, 0.5) = 99.61 um	D (v, 0.9) = 392.18 um
D [4, 3] = 156.18 um	D [3, 2] = 8.19 um	Span = 3.861E+00	Uniformity = 1.214E+00

Size (um)	Volume Under %	Size (um)	Volume Under %	Size (um)	Volume Under %	Size (um)	Volume Under %
0.055	0.00	0.635	1.73	7.31	9.70	84.15	46.04
0.061	0.01	0.700	1.85	8.06	10.47	92.79	48.31
0.067	0.02	0.772	1.97	8.89	11.28	102.3	50.65
0.074	0.03	0.851	2.09	9.80	12.15	112.8	53.09
0.082	0.04	0.938	2.22	10.81	13.06	124.4	55.62
0.090	0.06	1.03	2.36	11.91	14.02	137.2	58.25
0.099	0.08	1.14	2.51	13.14	15.04	151.3	60.99
0.109	0.11	1.26	2.67	14.49	16.10	166.8	63.83
0.121	0.15	1.39	2.84	15.97	17.23	183.9	66.79
0.133	0.19	1.53	3.02	17.62	18.40	202.8	69.86
0.147	0.24	1.69	3.22	19.42	19.64	223.6	73.03
0.162	0.30	1.86	3.43	21.42	20.94	246.6	76.21
0.178	0.37	2.05	3.67	23.62	22.31	271.9	79.37
0.196	0.44	2.26	3.92	26.04	23.74	299.8	82.44
0.217	0.53	2.49	4.20	28.72	25.24	330.6	85.37
0.239	0.62	2.75	4.51	31.66	26.82	364.6	88.11
0.263	0.72	3.03	4.85	34.92	28.46	402.0	90.61
0.290	0.82	3.34	5.22	38.50	30.16	443.3	92.84
0.320	0.93	3.69	5.63	42.45	31.94	488.8	94.78
0.353	1.04	4.07	6.08	46.81	33.78	539.0	96.40
0.389	1.15	4.48	6.57	51.62	35.67	594.3	97.72
0.429	1.27	4.94	7.10	56.92	37.63	655.4	98.75
0.473	1.38	5.45	7.68	62.76	39.64	722.7	99.48
0.522	1.50	6.01	8.30	69.21	41.71	796.9	99.86
0.576	1.61	6.63	8.98	76.32	43.84	878.7	100.00



Result: Histogram Report

Sample Details

Sample ID: CS00011SD5502

Run Number: 12

Measured: Wed Mar 8 2000 10:49AM

Sample File: 4159

Record Number: 28

Analysed: Wed Mar 8 2000 10:49AM

Sample Path: A:\

Result Source: Analysed

Sample Notes: BLASLAND, BOUCK & LEE Soil/ Sediment

Carrier: Water Dispersant: Triton X-100. Na Pyrophos

Ultrasonic: 1 minute Tech: AH

Particle Technology Labs PTL: 23410

System Details

Range Lens: 300RF mm

Beam Length: 2.40 mm

Sampler: MS17

Obscuration: 27.8 %

Presentation: 3OHD

[Particle R.I. = (1.5295, 0.1000); Dispersant R.I. = 1.3300]

Analysis Model: Polydisperse

Residual: 0.346 %

Modifications: None

Result Statistics

Distribution Type: Volume

Concentration = 0.0520 %Vol

Density = 1.000 g / cub. cm

Specific S.A. = 0.9985 sq. m / g

Mean Diameters:

D (v, 0.1) = 5.02 um

D (v, 0.5) = 64.28 um

D (v, 0.9) = 317.96 um

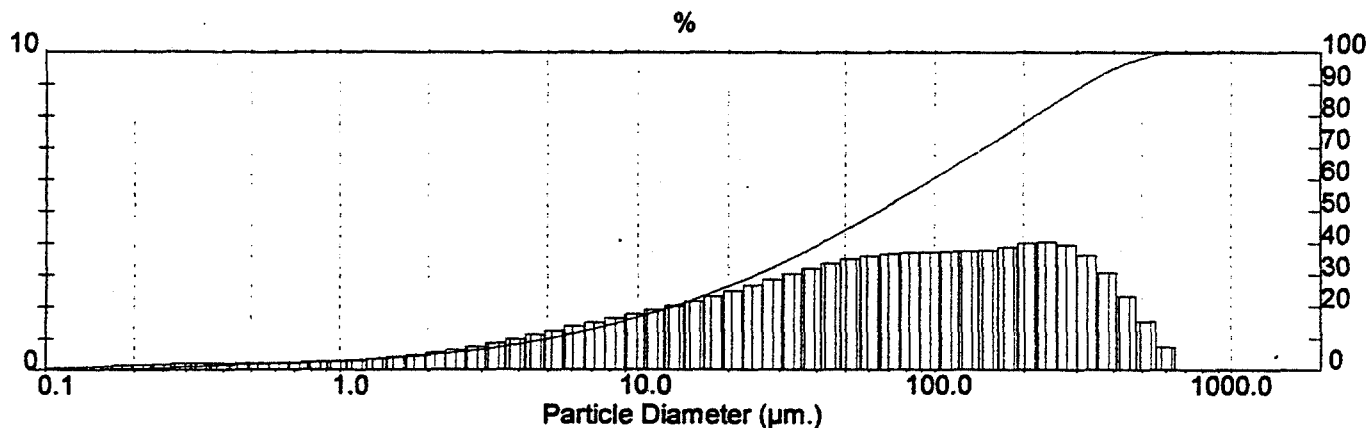
D [4, 3] = 117.68 um

D [3, 2] = 6.01 um

Span = 4.869E+00

Uniformity = 1.476E+00

Size (um)	Volume Under %	Size (um)	Volume Under %	Size (um)	Volume Under %	Size (um)	Volume Under %
0.055	0.00	0.635	2.37	7.31	13.38	84.15	56.48
0.061	0.01	0.700	2.52	8.06	14.39	92.79	58.86
0.067	0.02	0.772	2.67	8.89	15.45	102.3	61.25
0.074	0.04	0.851	2.83	9.80	16.56	112.8	63.64
0.082	0.06	0.938	3.00	10.81	17.72	124.4	66.04
0.090	0.09	1.03	3.19	11.91	18.94	137.2	68.45
0.099	0.13	1.14	3.38	13.14	20.21	151.3	70.87
0.109	0.17	1.26	3.60	14.49	21.54	166.8	73.30
0.121	0.22	1.39	3.83	15.97	22.92	183.9	75.78
0.133	0.28	1.53	4.08	17.62	24.37	202.8	78.31
0.147	0.36	1.69	4.36	19.42	25.88	223.6	80.88
0.162	0.44	1.86	4.67	21.42	27.46	246.6	83.47
0.178	0.53	2.05	5.00	23.62	29.10	271.9	86.04
0.196	0.64	2.26	5.37	26.04	30.82	299.8	88.55
0.217	0.76	2.49	5.78	28.72	32.62	330.6	90.93
0.239	0.89	2.75	6.22	31.66	34.49	364.6	93.12
0.263	1.02	3.03	6.71	34.92	36.43	402.0	95.05
0.290	1.17	3.34	7.24	38.50	38.44	443.3	96.69
0.320	1.32	3.69	7.83	42.45	40.53	488.8	98.00
0.353	1.47	4.07	8.46	46.81	42.68	539.0	98.98
0.389	1.62	4.48	9.15	51.62	44.88	594.3	99.71
0.429	1.77	4.94	9.89	56.92	47.14	655.4	100.00
0.473	1.92	5.45	10.68	62.76	49.44	722.7	100.00
0.522	2.07	6.01	11.53	69.21	51.76	796.9	100.00
0.576	2.22	6.63	12.43	76.32	54.11	878.7	100.00



Attachment 4

Two Tower Center Blvd.
10th Floor
East Brunswick, New Jersey 08816

CLH
CHEMICAL LAND HOLDINGS, INC.

September 20, 2000

U.S. Environmental Protection Agency, Region II
Emergency and Remedial Response Division
290 Broadway, 19th Floor, Room W-20
New York, NY 10007-1866

Attention: Ms. Janet Conetta
Strategic Integration Manager

Subject: Results of Centrifuge Comparison Test
Passaic River Study Area
Administrative Order on Consent Index No. II-CERCLA-0117

Dear Ms. Conetta:

Please find attached a memorandum from BBL reporting on the results of a comparison test between a continuous-flow centrifuge and a multiplate filtration system. This comparison was conducted in relation to the Combined Sewer Overflow (CSO) program that is pending under the Ecological Sampling Plan (ESP) of the Passaic River Remedial Investigation/Feasibility Study (RI/FS).

During the CSO Trial Run two major issues were noted when filtering the water to obtain solids:

- High water content – the water contained within the filters was having an adverse impact on the analytical results, resulting in qualified data
- Time – filtration of the large volume of water required to obtain sufficient solids mass was requiring excessive time and labor

As a result of these issues, CLH considered a number of mitigating actions, and proceeded with a comparison between the centrifuge and traditional filtration. The purpose of this letter is to provide the attached and, based on the superior performance of the centrifuge, recommend that the field centrifuge be used to collect solids from the CSO discharge instead of the multiplate filter. Since this represents a departure from the ESP, CLH is submitting this as a formal recommendation, and requests your prompt concurrence.

Background

Standard Operating Procedure (SOP) 6 of the ESP specifies that, if necessary, the CSO discharge water will be filtered through a 1.2 μ m filter to collect solids. Due to the large volume of water to be processed, a multi-plate filter was used to enable several filters to be coated with solids at the same time. During the CSO Trial Run task, it was taking several person-days to process the

82697146

required water volume. In addition, the water content of the samples was high, requiring the laboratories to qualify the analytical results due to high moisture content.

To rectify these issues, CLH considered a number of mitigation steps:

- Pump air or inert gas across the filters at the conclusion of each filter set. Based on experience, this would not reduce moisture content sufficiently, and would require even more labor/time to conduct the activity.
- Filter-press. This approach was judged to be promising to reduce moisture content, but would potentially cause the loss of solids and was particularly labor intensive.
- Continuous-flow centrifuge. This was judged to have the greatest potential to both reduce moisture content and labor/time for processing.

Results

CLH evaluated the performance of a portable centrifuge versus filtration to remove solids from a large volume of water. The two systems were compared for performance (i.e., the distribution of grain sizes removed) and for labor/time for processing. To conduct the evaluation, 400 gallons of Passaic River water were collected and kept homogenized with a power stirrer while collecting samples via the two methods. The attached memorandum from BBL provides additional detail on the process, the tests conducted, and the results.

Filtration was conducted with a single multiplate filter system (6 filters) and centrifugation was performed with a Westfalia centrifuge as modified by Machine All, Inc. of Ontario, Canada. Particle Technology Laboratories (Downers Grove, IL) analyzed the sediment samples for grain size distribution.

The attached table summarizes the performance characteristics of the two systems. The pertinent results are:

- Grain size distribution is essentially the same.
- Water content of the centrifuged sample is ~2/3 of the filtered sample – a significant improvement.
- The time/labor required for the centrifuge is less than half of that required for filtration.

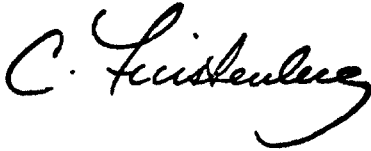
Based on these results, CLH is recommending that the centrifuge be used in lieu of filtration. The attached SOP 6 has been modified to allow the option for centrifugation, and to detail appropriate procedures to implement this method.

Ms. Janet Conetta
Results of Centrifuge Comparison Test
September 20, 2000
Page 3

Please indicate the Agency's concurrence with this improvement in writing.

If you have any questions, please contact me at (757) 258-7720.

Sincerely,

A handwritten signature in black ink, appearing to read "C. Firstenberg", with a stylized flourish at the end.

Clifford Firstenberg
Project Manager
On behalf of Occidental Chemical Corporation
(as successor to Diamond Shamrock Chemicals Company)

attachment

1. BBL Memorandum
2. Revised SOP 6

TABLE
COMPARISON OF RESULTS
Centrifugation versus Filtration

	CENTRIFUGATION	FILTRATION
Grain Size Distribution		
Particle Size (um)	Volume under (%)	Volume under (%)
0.522	3.71	3.54
1.03	6.02	5.68
2.05	9.47	8.92
4.94	19.24	19.38
9.80	35.12	37.56
19.42	58.07	61.95
51.62	87.56	88.30
102.3	95.79	95.28
202.8	99.03	98.49
299.8	99.94	99.75
Other Variables		
Moisture Content	~60%	~90%*
Time to process 400 gallons	~16 hours	~40 hours

- The 90% moisture content result is based on the Trial Run filtration results, not the comparison test results; only the centrifuged sample was analyzed for moisture content.

Ms. Janet Conetta
Results of Centrifuge Comparison Test
September 20, 2000
Page 5

- 1c: Section Chief
NJDEP-Bureau of Federal Case Management
401 East State Street -CN 028
Trenton, NJ 08625-0028
Attn: Jonathan D. Berg
- 1c: Chief, New Jersey Superfund Branch
Office of Regional Counsel
U.S. Environmental Protection Agency
290 Broadway, 19th Floor, Room W-20
New York, NY 10007-1866
Attention: Diamond Alkali Site Attorney - Passaic River Study Area

MEMORANDUM



To: Cliff Firstenberg
Chemical Land Holdings, Inc.

Date: 05/30/00

From: Russell Houck

cc: Tony Wolfskill
Robert Romagnoli
Lowell McBurney
Joe Molina
Doug Rusczyzk
Sarah Hill

Re: Centrifuge Demonstration
09994.104

This memorandum generally describes the centrifuge demonstration program conducted at the BBL Kearny field office between May 16 and May 19, 2000. At the request of CLH, this program was developed to evaluate the performance of the Westfalia centrifuge produced by Machine-All, Inc, Mississauga, Ontario, Canada.

Water Collection

On May 16, 2000, BBL collected 400 gallons of sediment-laden water from the Passaic River for use in the centrifuge demonstration. To collect the water, BBL transported equipment from the Kearny field office to the Kearny boat launch. At the boat launch area, two submersible pumps were placed within the Passaic River in approximately 1 to 2 feet of water. Pumps were placed inside perforated 5-gallon buckets to prevent intake of debris. During pumping, BBL personnel agitated river sediments in the area of the pumps to promote intake of suspended sediments. Once collected, water was then transported back to the Kearny field office for temporary storage.

Filterable Solids Collection

On May 18, 2000, BBL utilized a portion of the collected water to obtain a filterable solids sample for particle size analysis. The results from this test would help in evaluating the solids capture efficiency of the centrifuge. BBL used a 3-plate (6 filter) AXYS multiplate filtration system and peristaltic pump to collect the sample. Prior to filtering, the AXYS multiplate was deconned and the 400 gallon tank of river water was mixed using a power drill and long-stem paddle mixing tool. Water was kept mixed during the process by intermittently using the power mixer and a boat oar. Over the course of 49 minutes, approximately 13 ½ gallons of water were filtered, and three sets of six filters (18 total) were collected. All filters (containing a heavy black/green/brown film of wet solids) were placed in two 1-liter glass jars, labeled (sample ID: FILTSED01), and stored for shipment on the following day. Filtrate was collected and placed into 55-gallon storage drums and returned to the Passaic River the following day.

Centrifuge Demonstration

On May 19, 2000, BBL and Mr. Joe Kania of Machine-All, Inc. conducted a demonstration of the Westfalia centrifuge. The purpose of the demonstration was to test the system's ability to separate solids from water (especially fines). To conduct the demonstration, BBL/Machine-All set up the centrifuge system in the Kearny field office garage area. Initially, Mr. Kania instructed BBL personnel in the set-up, use and disassembly of the Westfalia centrifuge unit. Once CLH personnel (C. Firstenberg, T. Wolfskill) arrived on site, Mr. Kania, with BBL assistance, conducted a demonstration using approximately 20 grams of clay mixed with approximately 35 gallons of tap water. For this initial demonstration, the centrifuge operated at a rate of approximately 2 to 5 L/minute (average approximately 3.5 L/min) for approximately 35 minutes. Flow rate was checked and adjusted several times during the demonstration.

Following shutdown of the centrifuge and pump, the bowl assembly was removed and disassembled by Mr. Kania. A thin brown clay layer was visible on the inner bowl surfaces. Water and clay particles also remained in the base bowl. Several grams of wet sediment were scraped from the surface of one of the bowls. The bowl assembly was deconned and replaced for a second demonstration.

The centrifuge system was then set up to draw from the 400-gallon tank of river water. Prior to operating the centrifuge, the 400-gallon tank was mixed using the power drill/mixer and boat oar. During this second demonstration, the centrifuge ran for 50 minutes at a flow rate of approximately 1 to 2 L/minute (the flow rate was checked periodically at the discharge). Approximately 15 to 20 gallons of water was discharged from the centrifuge during the second demonstration. The bowl assembly was removed and disassembled.

A sediment layer of noticeable thickness was visible on the inner bowl surfaces. Sediment was black/green/brown in color. Water and sediment particles also remained in the base bowl. Using a plastic spatula, wet sediment was scraped from the surface of the bowls. Collected sediment was placed in a 250 ml glass jar (sample ID CENTSED01) and weighed. Total net weight of the collected sediment (wet) was 64.1 grams. The bowl assembly was then deconned.

Water discharged from the centrifuge was collected and returned to the 400 gallon tank. Water from collection of the filterable solids sample was also returned to the 400- gallon tank. The tank was then transported to the Kearny boat launch where the water was pumped back into the Passaic River.

The filterable solids sample (collected May 18, 2000) and the centrifuge sediment sample (collected May 19, 2000 during the second demonstration) were shipped via Fedex to Particle Technology Laboratories (PTL), Downers Grove, IL, for particle size analyses. In addition, the centrifuge sample was to be analyzed for moisture content.

Laboratory Results

On May 23, 2000, PTL faxed to BBL results from the particle size testing and moisture content analysis. Both the filterable solids sample (FILTSED01) and the centrifuge sample (CENTSED01) were analyzed for particle size using a Malvern S Laser particle size analyzer which utilizes a laser diffraction sizing technique. Histogram and tabular data from the particle size analyses are attached. Results show that, in general, the two sampling methodologies (filtering and centrifuge) captured similar fractions of particle sizes. A portion of the results are summarized below.

Particle size (um)	Filterable Solids Volume under (%)	Centrifuged Solids Volume under (%)
0.522	3.71	3.54
1.03	6.02	5.68
2.05	9.47	8.92
4.94	19.24	19.38
9.80	35.12	37.56
19.42	58.07	61.95
51.62	87.56	88.30
102.3	95.79	95.28
202.8	99.03	98.49
299.8	99.94	99.75

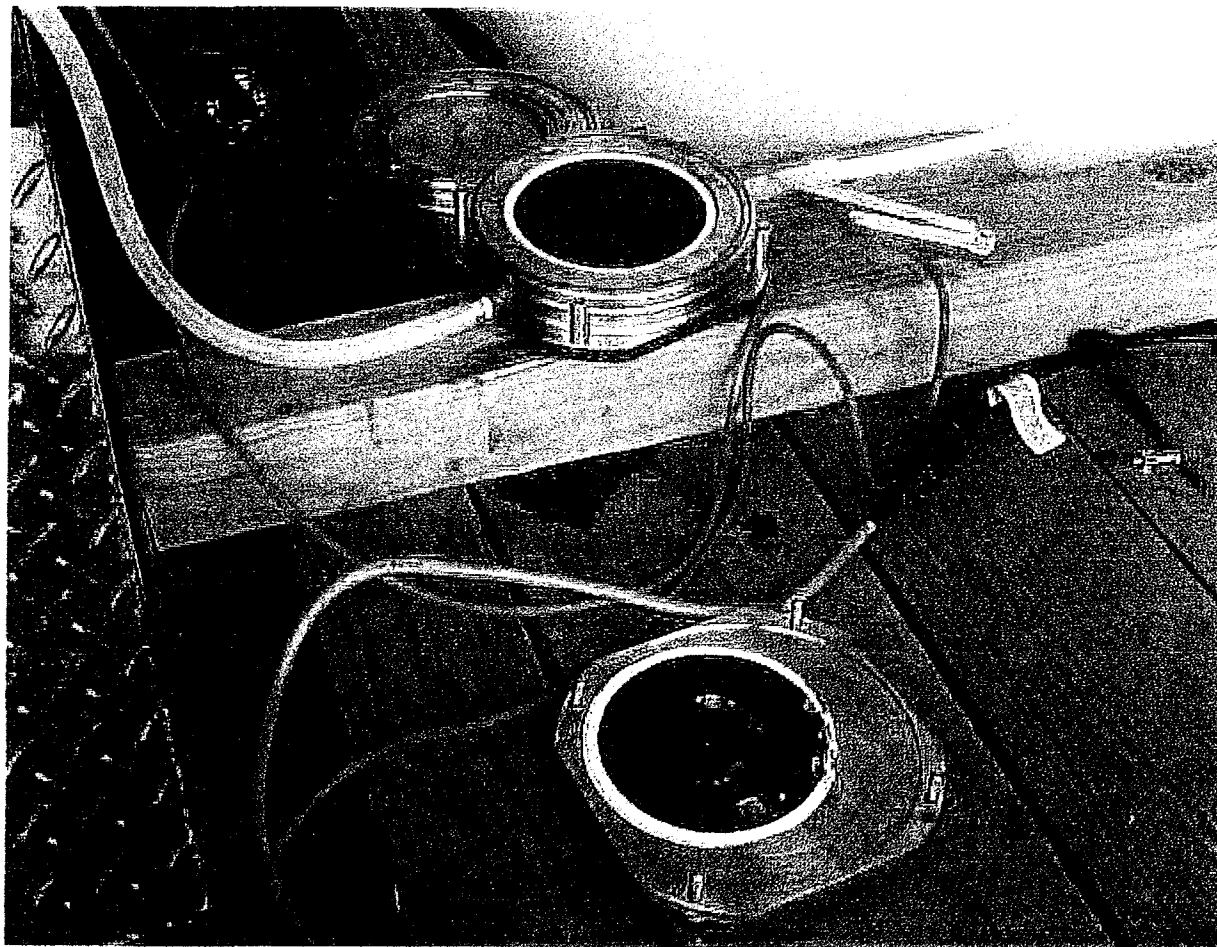
05/30/00

PTL also reported a moisture content of 67.3% for the centrifuge sediment sample. Based upon this moisture content and the wet weight of the sample, a total of approximately 21 grams of dry solids were captured during the 50 minute demonstration.

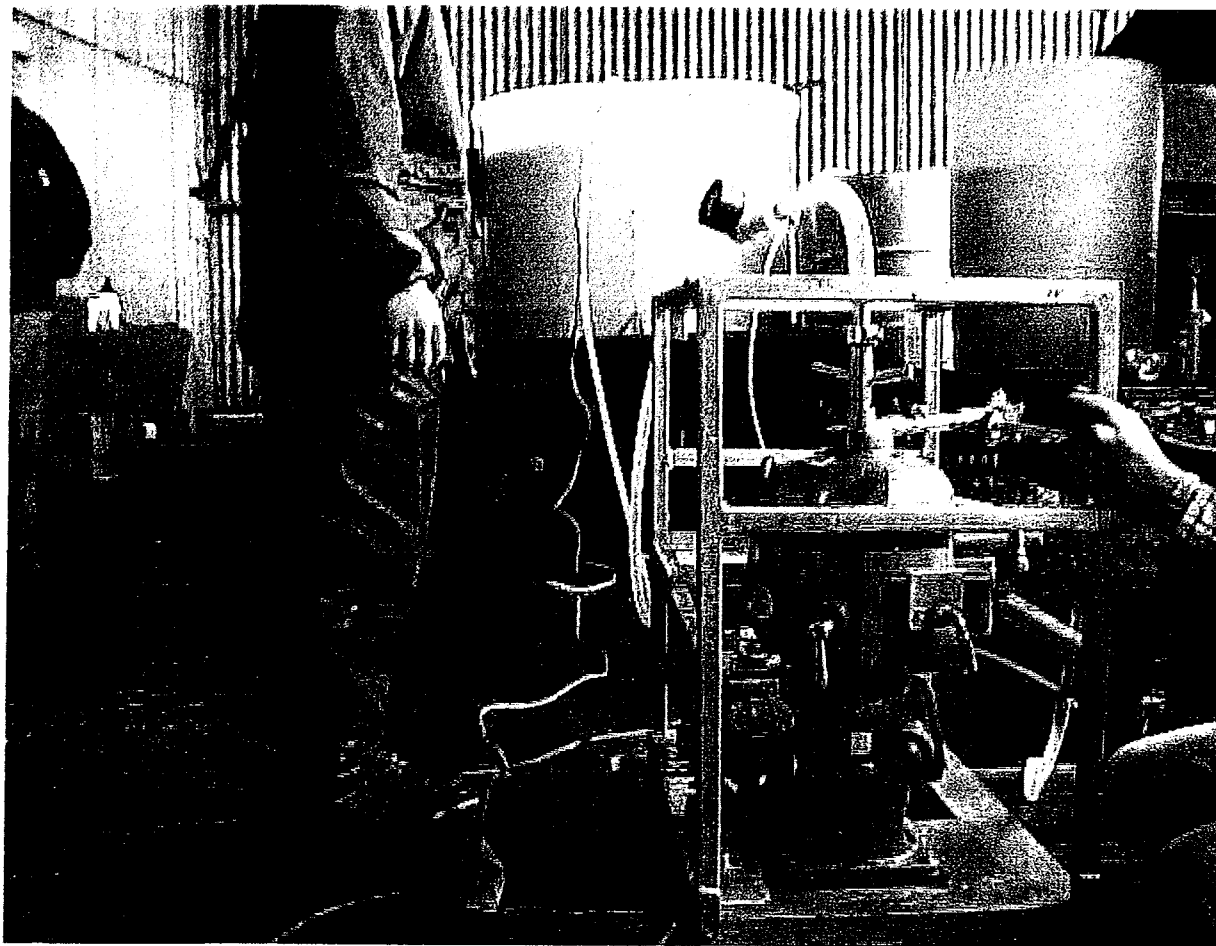
Based on the mass of dry solids collected (approximately 21 grams) and volume of water centrifuged (assume 20 gallons), the TSS level in the 400-gallon tank was approximately 300 mg/L. Note that this TSS level was greater than those previously measured for river samples (50-200 mg/L) and CSO samples (approximately 100 mg/L).

Digital photos taken of the filtered solids and centrifuge sample collection are attached.

REH/reh



MVC-005S Filter Collection – Multiplate filtration unit with 1.2 μ m filters



MVC-015S Centrifuge Demonstration – Centrifuge system – Passaic River water demo



MVC-029S Centrifuge Demonstration – 250 ml jar with 64 grams solids (wet wt.) after 50 min. of centrifuging

Particle Technology Labs, Ltd.



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FDA Certificate# 1422692

May 25, 2000

BLASLAND BOUCK & LEE, INC.
6723 Towpath Road
Syracuse, NY 13214

Attn: Mr. Russell Houck

Subject: Particle Size Analysis and Moisture Content of Two Particulate Samples

PTL Project: 4395

Dear Mr. Houck:

Enclosed are the results from the particle size analysis and moisture content conducted on your two Particulate samples received 5/22/00. The particle size was determined on our Malvern Mastersizer S LASER diffractor. For your Filters with sediment, one filter was selected at random and wetted with Triton X-100 and sodium pyrophosphate in water. The particulate was collected in a large beaker and ultrasonicated for a timed two minutes. An aliquot portion of the Centrifuged solids sample was wetted with Triton X-100 and sodium pyrophosphate in water and ultrasonicated for a timed two minutes. Both samples were analyzed according to standard operating procedures for this instrumentation type.

Please note that these samples were received in a very clumpy, agglomerated state. Therefore, the addition of wetting agents and the application of ultrasonic energy were used to aid in sample dispersion. Following the dispersion process, microscope examination revealed that these samples still contained floccy agglomerates which did not break apart during dispersion. These results reflect the inclusion of the floccy agglomerates.

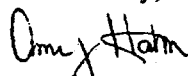
An explanation page entitled, "INTERPRETING YOUR MALVERN FINE PARTICLE ANALYSIS," has also been included for your review.

At you request, the moisture content was also determined for the Centrifuged Solids sample. The moisture content was determined to be:


Moisture Content: 67.3%

We trust this information will be beneficial for your future use. If there are any questions concerning this data or the methods used to acquire the data, please do not hesitate to contact us here at Particle Technology Labs.

Submitted by,


Amy Hahn

Reviewed by,


Kelli Hubert

DR:\4395.doc:391

Particle Technology Labs, Ltd.



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FDA Certificate# 1422692

INTERPRETING YOUR MALVERN FINE PARTICLE ANALYSIS

INTRODUCTION

Your samples have been analyzed on a Malvern MasterSizer S LASER particle size analyzer. This instrument analyzes particles on an ensemble basis, calculating a volume distribution from the LASER diffraction pattern of particle diameters.

THE REPORT

The information presented in your report consists of four basic categories:

SAMPLE DETAILS: The first section of the report page consists of **SAMPLE DETAILS:** client, sample identification, and sample conditioning information. If you find it necessary to contact us concerning this work, please refer to the four-digit PTL Project #, which appears under *Sample File*.

SYSTEM DETAILS: This section describes parameters specific to the instrument being used as well as to the analysis. It should be noted that in the size region of 0.1 - 3 microns, LASER technology is sensitive to the refractive index (RI) of the sample material. Therefore, a standard instrument default value for the refractive index of the sample and carrier fluid is normally used if one is not provided by the client. A sample RI value of 1.5295 (glass beads) is used along with a carrier fluid RI of 1.33 (water). Likewise, the **Presentation: OHD** and **Analysis Model: Polydisperse** is used as a default. For samples analyzed on a **dry** basis, the particle RI is 1.45 with a dispersant RI of 1.00 (air). Correspondingly, the **Presentation: RHA** is used as the default. If the client provides a RI at a later date, the raw data can be recalculated to adjust for the refractive index.

RESULT STATISTICS: This section presents

1. Statistics
 - A. ***Statistics **ALWAYS** appear as "Percent Less Than" or "% Under."***
 - B. Span is defined as the 90% - 10% size divided by the 50% size level.
 - C. The Surface to Volume mean diameter is reported as the **D[3,2]** value.
 - D. The Mean Volume statistic is reported as the **D[4,3]** value.
 - E. The 90%, 50%, and the 10% size values appear as **D[v,0.90]**, **D[v,0.50]** and **D[v,0.10]** respectively.
 - F. A calculated Specific Surface Area value is reported. However, consider this value only as an approximate surface area since calculations are based upon **smooth spheres**.
2. Tabulated data as a **Cumulative Weight Percent Greater Than (Or Less Than) Indicated Size**.

HISTOGRAM: This last section displays the differential histogram as well as the cumulative curve for the data displayed in the table above.

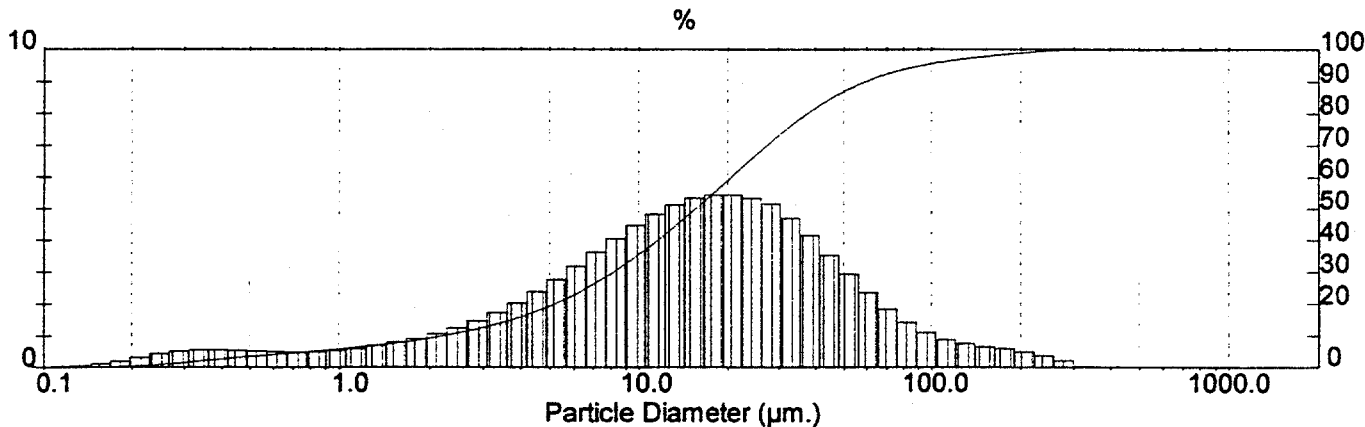
Result: Histogram Report

Sample Details		
Sample ID: FILTERSED01	Run Number: 2	Measured: Tue May 23 2000 9:52AM
Sample File: 4395	Record Number: 2	Analysed: Tue May 23 2000 9:52AM
Sample Path: A:\		Result Source: Analysed
Sample Notes: BLASLAND BOUCK & LEE	Filters with Sediment	
Carrier: Water	Dispersant: Na Pyrophos., Triton X-100	
Ultrasonic: 2 minutes	Tech: AH	
Particle Technology Labs	PTL: 24297	

System Details			
Range Lens: 300RF mm	Beam Length: 2.40 mm	Sampler: MS1	Obscuration: 27.7 %
Presentation: 3OHD	[Particle R.I. = (1.5295, 0.1000);	Dispersant R.I. = 1.3300]	
Analysis Model: Polydisperse			Residual: 0.442 %
Modifications: None			

Result Statistics			
Distribution Type: Volume	Concentration = 0.0267 %Vol	Density = 1.000 g / cub. cm	Specific S.A. = 1.6175 sq. m / g
Mean Diameters:	D (v, 0.1) = 2.21 um	D (v, 0.5) = 15.48 um	D (v, 0.9) = 59.24 um
D [4, 3] = 26.83 um	D [3, 2] = 3.71 um	Span = 3.685E+00	Uniformity = 1.287E+00

Size (um)	Volume Under %	Size (um)	Volume Under %	Size (um)	Volume Under %	Size (um)	Volume Under %
0.055	0.00	0.635	4.38	7.31	27.26	84.15	94.29
0.061	0.00	0.700	4.69	8.06	29.71	92.79	95.10
0.067	0.00	0.772	5.01	8.89	32.33	102.3	95.79
0.074	0.01	0.851	5.33	9.80	35.12	112.8	96.39
0.082	0.01	0.938	5.67	10.81	38.06	124.4	96.93
0.090	0.02	1.03	6.02	11.91	41.15	137.2	97.41
0.099	0.03	1.14	6.40	13.14	44.37	151.3	97.86
0.109	0.05	1.26	6.81	14.49	47.70	166.8	98.28
0.121	0.07	1.39	7.25	15.97	51.11	183.9	98.67
0.133	0.11	1.53	7.74	17.62	54.58	202.8	99.03
0.147	0.17	1.69	8.26	19.42	58.07	223.6	99.35
0.162	0.25	1.86	8.84	21.42	61.56	246.6	99.61
0.178	0.36	2.05	9.47	23.62	65.01	271.9	99.82
0.196	0.50	2.26	10.17	26.04	68.41	299.8	99.94
0.217	0.69	2.49	10.94	28.72	71.76	330.6	99.98
0.239	0.93	2.75	11.79	31.66	74.96	364.6	100.00
0.263	1.22	3.03	12.73	34.92	77.95	402.0	100.00
0.290	1.55	3.34	13.78	38.50	80.72	443.3	100.00
0.320	1.91	3.69	14.94	42.45	83.25	488.8	100.00
0.353	2.28	4.07	16.23	46.81	85.53	539.0	100.00
0.389	2.65	4.48	17.66	51.62	87.56	594.3	100.00
0.429	3.01	4.94	19.24	56.92	89.34	655.4	100.00
0.473	3.37	5.45	20.99	62.76	90.88	722.7	100.00
0.522	3.71	6.01	22.91	69.21	92.21	796.9	100.00
0.576	4.05	6.63	25.00	76.32	93.34	878.7	100.00



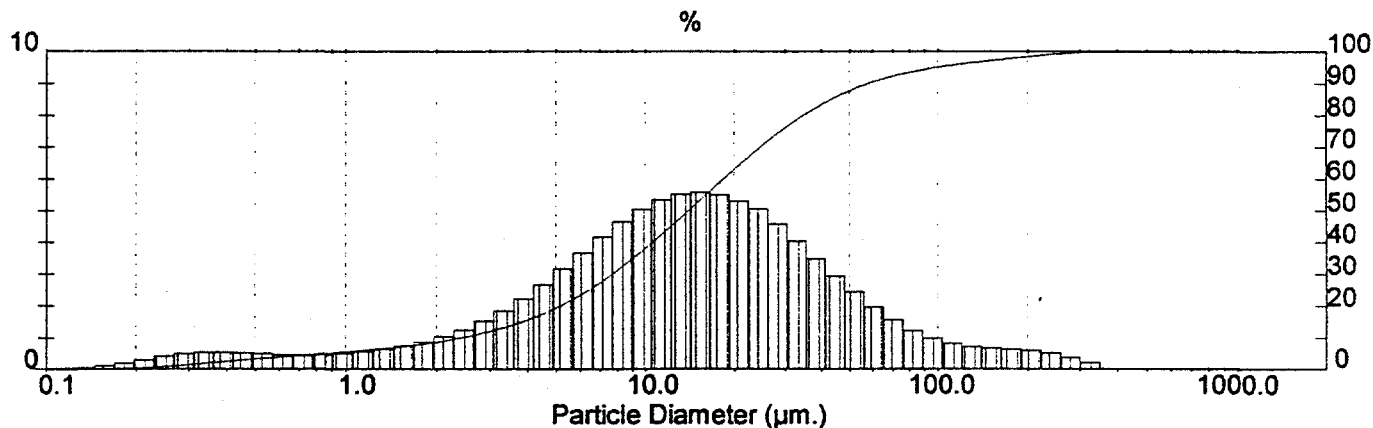
Result: Histogram Report

Sample Details		
Sample ID: CENTSED01	Run Number: 2	Measured: Tue May 23 2000 10:33AM
Sample File: 4395	Record Number: 6	Analysed: Tue May 23 2000 10:33AM
Sample Path: A:\		Result Source: Analysed
Sample Notes: BLASLAND BOUCK & LEE	Centrifuged Solids	
Carrier: Water	Dispersant: Na Pyrophos., Triton X-100	
Ultrasonic: 2 minutes	Tech: AH	
Particle Technology Labs	PTL: 24296	

System Details		
Range Lens: 300RF mm	Beam Length: 2.40 mm	Sampler: MS1
Presentation: 3OHD	[Particle R.I. = (1.5295, 0.1000);	Dispersant R.I. = 1.3300]
Analysis Model: Polydisperse		Obscuration: 28.5 %
Modifications: None		Residual: 0.385 %

Result Statistics			
Distribution Type: Volume	Concentration = 0.0275 %Vol	Density = 1.000 g / cub. cm	Specific S.A. = 1.5892 sq. m / g
Mean Diameters:	D (v, 0.1) = 2.38 um	D (v, 0.5) = 13.96 um	D (v, 0.9) = 57.84 um
D [4, 3] = 26.75 um	D [3, 2] = 3.78 um	Span = 3.971E+00	Uniformity = 1.452E+00

Size (um)	Volume Under %	Size (um)	Volume Under %	Size (um)	Volume Under %	Size (um)	Volume Under %
0.055	0.00	0.635	4.16	7.31	28.58	84.15	93.95
0.061	0.00	0.700	4.45	8.06	31.39	92.79	94.66
0.067	0.00	0.772	4.74	8.89	34.39	102.3	95.28
0.074	0.01	0.851	5.04	9.80	37.56	112.8	95.83
0.082	0.01	0.938	5.35	10.81	40.87	124.4	96.33
0.090	0.02	1.03	5.68	11.91	44.29	137.2	96.79
0.099	0.03	1.14	6.02	13.14	47.79	151.3	97.24
0.109	0.04	1.26	6.40	14.49	51.34	166.8	97.67
0.121	0.07	1.39	6.81	15.97	54.91	183.9	98.09
0.133	0.11	1.53	7.26	17.62	58.46	202.8	98.49
0.147	0.16	1.69	7.76	19.42	61.95	223.6	98.88
0.162	0.24	1.86	8.31	21.42	65.37	246.6	99.23
0.178	0.34	2.05	8.92	23.62	68.70	271.9	99.52
0.196	0.48	2.26	9.60	26.04	71.91	299.8	99.75
0.217	0.66	2.49	10.38	28.72	74.92	330.6	99.95
0.239	0.89	2.75	11.25	31.66	77.70	364.6	100.00
0.263	1.17	3.03	12.23	34.92	80.27	402.0	100.00
0.290	1.49	3.34	13.34	38.50	82.61	443.3	100.00
0.320	1.83	3.69	14.59	42.45	84.73	488.8	100.00
0.353	2.18	4.07	16.01	46.81	86.62	539.0	100.00
0.389	2.53	4.48	17.60	51.62	88.30	594.3	100.00
0.429	2.88	4.94	19.38	56.92	89.78	655.4	100.00
0.473	3.21	5.45	21.37	62.76	91.06	722.7	100.00
0.522	3.54	6.01	23.57	69.21	92.17	796.9	100.00
0.576	3.86	6.63	25.97	76.32	93.13	878.7	100.00



**ECOLOGICAL SAMPLING PLAN FOR THE
PASSAIC RIVER STUDY AREA**

STANDARD OPERATING PROCEDURE NO. 6

COMBINED SEWER OVERFLOW SAMPLING

September 2000

TABLE OF CONTENTS

<u>Section</u>	<u>Page</u>
1.0 APPLICABILITY	3
2.0 PREPARATIONS FOR SAMPLING	3
3.0 FIELD EQUIPMENT LIST	3
4.0 DECONTAMINATION OF EQUIPMENT	4
5.0 LOCATION OF SAMPLING STATIONS	4
6.0 CSO SAMPLE COLLECTION AND PREPARATION	5
6.1 Automated Sampling Procedure	5
6.2 Alternative Manual Sampling Procedure	6
6.3 CSO Effluent Sampling Preparation	7
6.4 CSO Settleable Solids Collection	8
6.5 CSO Solids Collection from CSO Effluent	9
6.5.1 Centrifugation Methodology	9
6.5.2 Filtration Methodology	12
7.0 SAMPLE CONTAINERS, PRESERVATION, HANDLING AND TRACKING	14
8.0 QUALITY CONTROL SAMPLES	14

1.0 APPLICABILITY

This Standard Operating Procedure (SOP) defines one of the procedures which will be followed for the collection and preparation of combined sewer overflow (CSO) effluent and solids samples from the Passaic River Study Area (Study Area). These procedures give descriptions of equipment and field procedures necessary to collect CSO samples in this manner. SOP-14 provides an alternate method for collection of CSO solids.

Other SOPs that will be utilized with this procedure include:

- SOP No. 1 - Decontamination
 - SOP No. 2 - Containers, Preservation, Handling and Tracking of Sample
 - SOP No. 5 - Surface Water Quality Physicochemical Parameters

2.0 PREPARATIONS FOR SAMPLING

The FSP identifies the process for the selection of CSO sampling stations, the frequency of sampling, sample type, field measurements, and analytical procedures for this study element. The field team is responsible for reviewing the FSP prior to conducting field activities and ensuring that all field equipment, including sample containers and preservatives, are available and in acceptable condition.

3.0 FIELD EQUIPMENT LIST

Equipment to be used during the collection of CSO effluent samples (including water and solids) will depend on the collection methodologies selected in this SOP. Equipment may include, but is not limited to, the following:

- 900 Lite Sigma Stormwater Sampler with built-in rain gauge, integral flow meter, and electronic depth sensor, temperature/pH meter, dissolved oxygen/conductivity meter (or equivalent), and a maximum pump flow rate of 1500 ml/min at 3 ft vertical lift
- Backup temperature/pH meter, and dissolved oxygen/conductivity meter
- Field monitoring equipment (OVA or HNu, and CGI/O₂ meter)

SUPERSEDED

- Sample collection containers
- Preservatives (as required)
- 6 gallon (23 liter) polyethylene container
- 300-400 gallon trailer-mounted polyethylene holding tank
- Westfalia Centrifuge (modified by Machine All, Inc., Ontario, Canada)
- Submersible pump (stainless steel/Teflon)
- Filtration unit
- 1.2 um glass fiber filters
- Peristaltic or centripetal pump
- Teflon (or equivalent) tubing
- Spill containment container/pan
- Laboratory sample containers
- Wet Ice
- Insulated coolers
- Sample identification labels
- Tape
- Waterproof marking pens
- Sealable plastic bags and bubble wrap
- Litmus test strips for confirming proper sample preservation
- Power mixer (for 400 gallon tank; stainless steel blade)
- Decontamination equipment

4.0 DECONTAMINATION OF EQUIPMENT

Decontamination of CSO sampling equipment will be performed prior to the initial set-up and between each sampling event at each location in accordance with procedures outlined in SOP No. 1 - Decontamination. Personnel decontamination procedures are contained in the HASP.

5.0 LOCATION OF SAMPLING STATIONS

The selection process of the CSOs to be sampled is described in the FSP. Once on location, the manhole access where the samples will be collected will be established and labeled on a map.

6.0 CSO SAMPLE COLLECTION AND PREPARATION

The following procedure shall be implemented, as practicable, for collecting CSO samples from operable and accessible CSOs that discharge into the Study Area. The analytical sample volume requirements for the aqueous effluent samples and the solids samples are provided in Tables 4-1 and 4-2 of the QAPP, respectively. Samples will be preserved in the field following compositing (described below). The following list presents the procedures to be followed during CSO effluent and CSO solid sample collection, preservation and processing.

6.1 Automated Sampling Procedure

1. The automated sampling equipment (if used) will be securely mounted either 1) inside the manhole that is selected for sampling, 2) inside the CSO discharge pipe, or 3) in a protected location adjacent to the discharge pipe with the equipment probes secured inside the CSO. A 6 gallon polyethylene container will be set up inside the housing of the portable sampler. This container will be used to collect a 30 minute continuous composite of the first-flush, and allow sufficient time for mobilization of the 300-400 gallon holding tank to the CSO location for additional sample collection.
2. Check automated sampler calibrations/settings and monitoring equipment calibrations/settings per operation manuals (as appropriate).
3. Record the sampling location position and the depth of the water within the CSO pipe at the sampling location (if appropriate) in the field logbook.
4. Program the automated sampler to begin sampling when an internal flow/depth sensing device (which includes an area-velocity flow meter coupled to the sampling system and a probe that is in the channel beside the intake tubing) indicates an increase in positive flow and/or depth. Program the system to recognize and not sample negative flow (*i.e.*, backflow) which may result from tidal influence and river water entering the outfall.

- SUPERSEDED**
5. Initiate the autosampler modem/personal beeper equipment to notify a designated field team member when the sampler begins collection during an overflow event.
 6. Following notification by the autosampler modem that collection has started, mobilize the trailer mounted with the 300 - 400 gallon capacity polyethylene container (hopper bin) to the CSO location. This holding tank will be opened on top and have a ball valve on the bottom which can be used for sample collection.
 7. Transfer the discharge tubing from the 6 gallon polyethylene container in the manhole to the larger holding tank on the trailer. Empty the 6 gallon sample container into the larger holding tank. Continue pumping until the end of the overflow event or until the holding tank is full. If the sample container is filled prior to the end of the overflow event, flow, pH, temperature, dissolved oxygen, and conductivity will continue to be automatically monitored for the duration of the storm.
 8. Transport the container to the staging area. Collect aqueous effluent samples for chemical analyses following procedures outlined in Section 6.3.

6.2 Alternative Manual Sampling Procedure

This alternative manual procedure may be required if an automated sampler is not used, or if there is pump or other system failure of the automated sampler.

1. Measure and record temperature, dissolved oxygen, salinity/conductivity, and pH in the discharging water from the CSO pipe in accordance with SOP No. 5 - Surface Water Physicochemical Parameters. These measurements can be made directly from the pipe or a grab sample. The frequency of these measurements should be a minimum of every fifteen minutes unless field conditions limit the field teams' ability to sample at that frequency.

2. Initiate flow and depth measurement at the first indication of overflow. This information will be collected every 15 minutes during sample collection and logged in the field logbook.
3. Set the submersible pump (or equivalent) in the water column of the CSO pipe to initiate sample collection with the first flush and continue to sample until the 300-400 gallon holding tank is full, or the storm event is over.
4. Transport the holding tank to the staging area. Collect aqueous effluent samples for chemical analyses following procedures outlined in Section 6.3.

6.3 CSO Effluent Sample Preparation

Upon arrival at the staging area or an appropriately identified staging area the CSO effluent samples will be prepared for shipment to the analytical laboratory(s). Both unfiltered and field filtered samples will be collected for analysis. The procedure for this sample collection is outlined below.

1. Homogenize the effluent sample in the holding tank.
2. Collect effluent samples from the 300-400 gallon holding tank using a decontaminated beaker, bailer, or other sampling equipment.
3. Transfer to the appropriate laboratory sample containers by gently pouring the collected sample into the appropriate containers by allowing the sample to flow slowly down the interior of the laboratory sample containers. The sample bottles should be alternated during the filling process.
4. Add preservative to laboratory sample containers as specified in Table 4-1 of QAPP.
5. Label the sample containers with the appropriate pre-printed sample identification labels.
6. Close and seal each container. Proceed with Step No. 8 for the unfiltered samples.

- SUPERSEDED**
7. Transfer samples for filtering into the hand pump at an appropriate rate to avoid overflow. Pump the appropriate sample volume through a 0.45 micron glass fiber filter(s). Transfer the filtrate into the appropriate laboratory sample container and label with the appropriate pre-printed sample identification labels. Discard the filters.
 8. Check label on each sample container and cover the label with clear plastic tape.
 9. Wrap sample containers in bubble wrap and place in a sealable plastic bag. Place bag in refrigerator until sample is ready for packing and shipping.
 10. Complete the appropriate chain-of-custody form for each sample container, and seal in plastic bag.
 11. Pack samples in shipping cooler with ice. Tape completed chain-of-custody form on the inside of the lid of the shipping cooler and seal cooler with tape and custody seals. Ship within 24 hours of collection by overnight courier to the appropriate laboratory.

6.4 CSO Settleable Solids Collection

1. Allow the suspended solids to settle in the holding tank undisturbed for up to 48 hours.
2. Collect settled solid samples from bottom of tank using a shovel or equivalent sediment collection equipment. If insufficient solids are collected, filter the effluent following the procedures described in Section 6.5.
3. Transfer solids to a decontaminated tared glass or stainless steel container and weigh on an electronic balance capable of weighing to the nearest 0.1g. Remove any non-sediment debris, weigh and determine whether sufficient mass has been collected, as required in Table 2-5 of the FSP. Continue removing settled solids from composite tank until the target mass has been reached. Homogenize the solids.

SUPERSEDED

4. If sufficient mass has been collected, transfer the settled solids to the appropriately labeled containers. Close and seal each container.
5. Check the label on each sample container and cover the label with clear plastic tape.
6. Wrap sample containers in bubble wrap and place in a sealable plastic bag. Place bag in refrigerator until sample is ready for packing and shipping.
7. Complete the appropriate chain-of-custody form for each sample container, and seal in plastic bag.
8. Pack samples in shipping cooler with wet ice. Tape completed chain-of-custody form on the inside of the lid of the shipping cooler and seal cooler with tape and custody seals. Ship within 24 hours of collection by overnight courier to the appropriate laboratory.

6.5 CSO Solids Collection from CSO Effluent

If an adequate quantity of solids are not collected via settling (as described in Section 6.4), additional solids will be obtained from the CSO effluent using either centrifugation or filtration methodologies. The centrifuge methodology will be the preferred methodology, if feasible. Solids collection protocols for both methodologies are detailed below.

6.5.1 Centrifugation Methodology

1. Mix CSO effluent in 400 gallon tank with power mixer; continue mixing throughout centrifugation process.
2. Transfer the appropriate volume of homogenized CSO effluent to the TSS and TOC sample containers. Add preservatives to the TOC container, label, and seal. Place in refrigerator or cooler until ready for shipment.

- SUPERSEDED**
3. Label the appropriate sample containers with the pre-printed sample identification labels.
 4. Set centrifuge on level surface to ensure stability. Disassemble bowl components.
 5. Decontaminate the centrifuge bowl components in accordance with the procedures outlined in SOP No. 1 - Decontamination.
 6. Reassemble the centrifuge bowl components and reattach to the centrifuge in accordance with the Machine All operation manual. Make sure that the drain spigot is not near the electrical panel. Tape the spring clamps in place to prevent loosening due to vibration. Attach the drain lines and ensure that the centrifuge has been checked for any loose materials, etc.
 7. Place the submersible pump in the 400-gallon tank. Do not hook the pump to the centrifuge yet.
 8. Place the outlet hose from the pump over the rim of the 400-gallon tank. Start the pump and adjust the valve on the water line to achieve a flow rate of 1-2 liters per minute. Turn the pump off and secure the outlet hose to the centrifuge.
 9. Start the centrifuge and wait until the machine is up to speed. When the centrifuge is at speed, turn the pump on and watch for the water to exit the drain pipe. The back-pressure valve should be adjusted so that there are no bubbles in the sight glass on the discharge pipe.
 10. Record the flow rate every 10 - 15 minutes and adjust as required.
 11. At the completion of centrifugation, turn off the pump and disconnect the outlet hose from the centrifuge. After all water has stopped flowing from the centrifuge discharge pipe, turn the centrifuge off.

- SUPERSEDED**
12. Remove the bowl and take to a flat, solid, clean area to disassemble. Remove the centrifuge bowl pump and, without taking the bowl apart, drain off all remaining water from the bowl into a decontaminated squeeze bottle, with excess water stored in a decontaminated sample bottle. This water will be used to (1) rinse material from the bowl assembly and (2) provide additional material, if needed, by drying.
 13. Disassemble the bowl, placing each section inside the other so as not to cause any contamination.
 14. Clean each section starting with the innermost triangular section and work outward. Use a Teflon spatula to remove solids from the bowl surfaces into a decontaminated stainless steel or glass container. After loosening the material with a brush and spatula, use the squeeze bottle to sparingly wash each section into a separate decontaminated container. After all sections have been cleaned, pour all of the water captured from the bowl and squeeze bottle into a sample container.
 15. Properly decontaminate the bowl pieces in accordance with SOP 1 - Decontamination and store all equipment appropriately.
 16. Weigh the collected solids/sample container to determine whether sufficient mass has been collected, as required in Table 2-5 of the FSP. Continue centrifugation until the target mass has been reached.
 17. When sufficient mass has been collected, homogenize and transfer the collected solids to the appropriately labeled containers. Close and seal each container. If, at the conclusion of centrifugation of the whole 400 gallons, insufficient mass has been collected, prepare additional sample containers with the retained rinse water to be submitted to the laboratories for drying.

- SUPERSEDED**
18. Check the label on each sample container and cover the label with clear plastic tape.
 19. Wrap sample containers in bubble wrap and place in a sealable plastic bag. Place bag in refrigerator until sample is ready for packing and shipping.
 20. Complete the appropriate chain-of-custody form for each sample container, and seal in plastic bag.
 21. Pack samples in shipping cooler with ice. Tape completed chain-of-custody form on the inside of the lid of the shipping cooler and seal cooler with tape and custody seals. Ship within 24 hours of collection by overnight courier to the appropriate laboratory.

6.5.2 Filtration Methodology

1. Mix CSO effluent in the 400-gallon tank with power mixer; continue mixing throughout filtering process.
2. Transfer the appropriate volume of homogenized CSO effluent to the TSS and TOC sample containers. Add preservatives to the TOC container, label, and seal. Place in refrigerator or cooler until ready for shipment.
3. Label the appropriate sample containers with the pre-printed sample identification labels.
4. Place the decontaminated 1.2 μm filter in the filtering apparatus. Start the vacuum or hand pump and add an appropriate volume of homogenized effluent sample.
5. Continue to add effluent sample until the filtrate container is full, or the filtering time slows, whichever comes first. Carefully remove the filter with forceps and place on a decontaminated glass plate. Retain 50-mL of filtrate

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for apparatus, rinse, and decant the remaining filtrate into a container for subsequent disposal. Add a new filter and resume filtration.

6. If the filtering process is slow, or visual inspection of the effluent suggests that there is a large concentration of suspended solids, sequential filtration may be required. In this case, the effluent is initially passed through the 10 μm filters, followed by filtering with the 1.2 μm filter.
7. Rinse the filtering apparatus with the retained filtrate to ensure that all of the solids have been removed from the sides of the filter holder.
8. Scrape the solids from the filters, using a decontaminated stainless steel spatula, onto a tared glass plate, taking care to not remove any filter media. Remove any non-sediment debris, weigh and determine whether sufficient mass is collected. Continue filtering until the target mass has been reached.
9. If sufficient mass has been collected, homogenize, and transfer the filtered sediment to the appropriately labeled containers. Close and seal each container.
10. Check the label on each sample container and cover the label with clear plastic tape.
11. Wrap sample containers in bubble wrap and place in a sealable plastic bag. Place bag in refrigerator until sample is ready for packing and shipping.
12. Complete the appropriate chain-of-custody form for each sample container, and seal in plastic bag.
13. Pack samples in shipping cooler with ice. Tape completed chain-of-custody form on the inside of the lid of the shipping cooler and seal cooler with tape and custody seals. Ship within 24 hours of collection by overnight courier to the appropriate laboratory.

7.0 SAMPLE CONTAINERS, PRESERVATION, HANDLING AND TRACKING

Sample containers, handling and preservation procedures are described in SOP No. 2 - Containers, Preservation, Handling and Tracking of Samples for Analysis.

8.0 QUALITY CONTROL SAMPLES

To identify potential sources of sample contamination and evaluate potential error introduced by sample collection and handling, field quality control samples (QC samples) will be collected during the CSO sample collection. All QC samples will be labeled in accordance with SOP No. 2 - Containers, Preservation, Handling and Tracking of Samples, and sent to the laboratory with the other samples for analysis. QC samples for CSO sampling will include rinsate samples, field duplicate samples, and matrix spike samples and will be collected at the frequency identified in the QAPP.